Plant Nutrients
and Stimulators

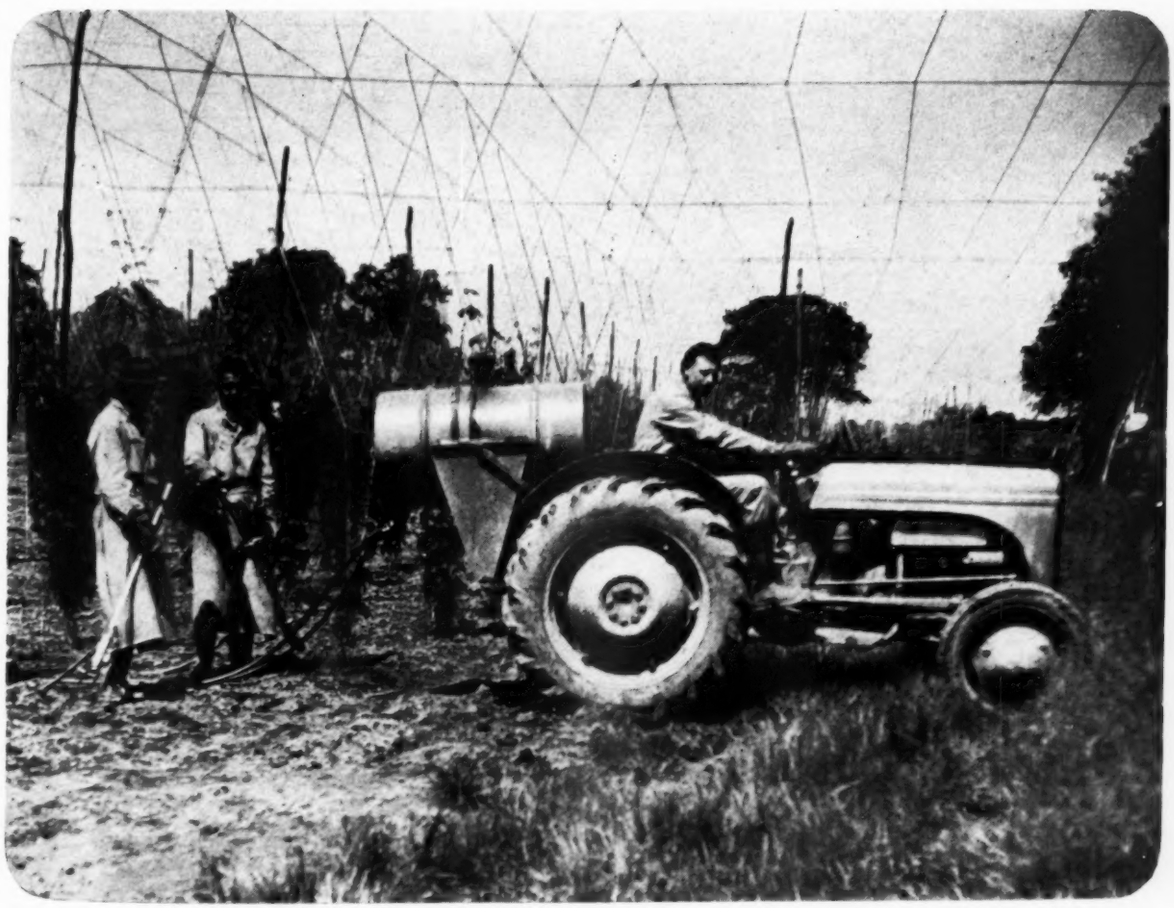
WORLD CROPS

The International Journal of Agriculture

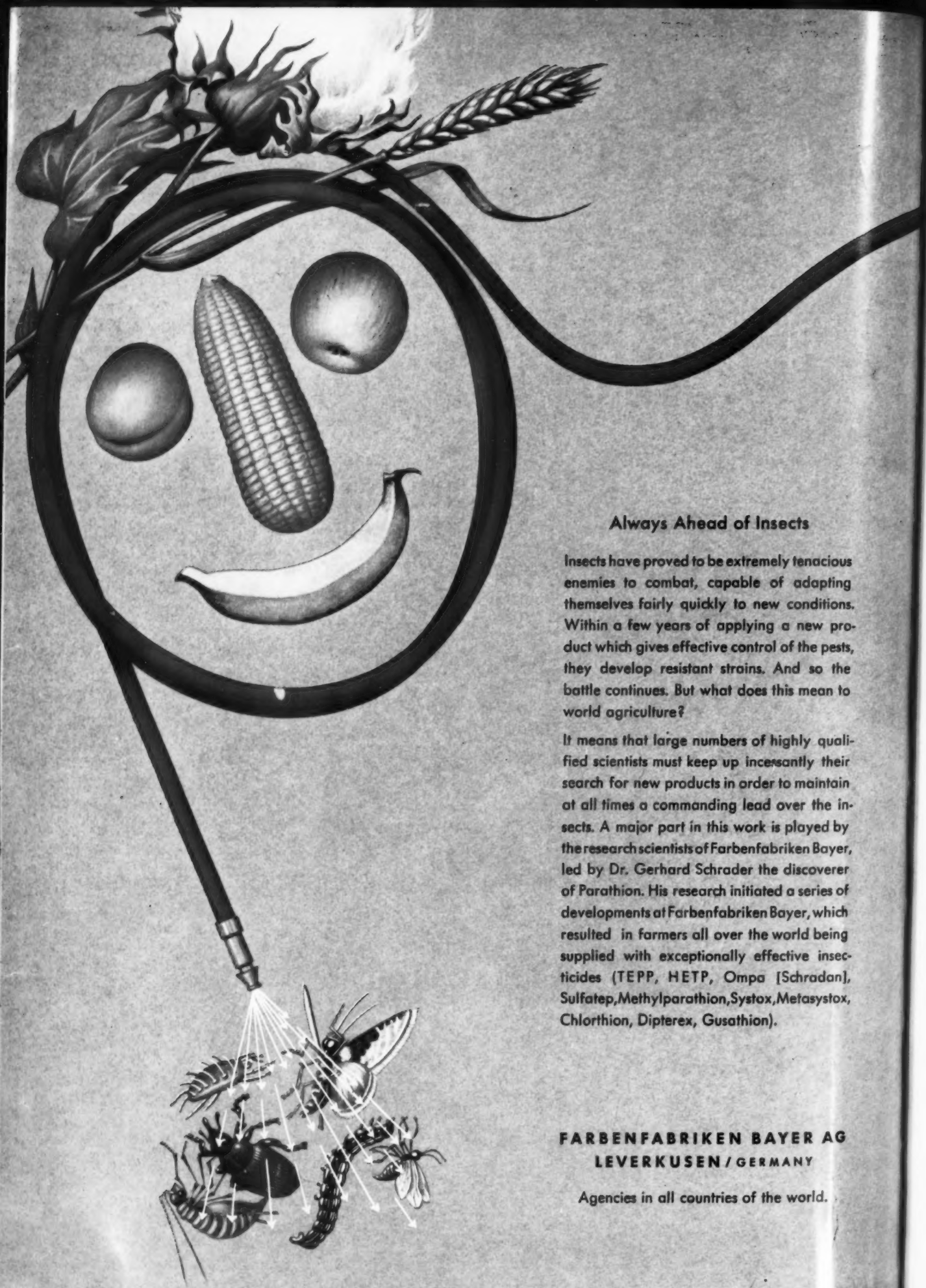
UNIVERSITY OF MICHIGAN
AUG 9 1958
FORESTRY LIBRARY

VOLUME 10, No. 9 SEPTEMBER 1958

A Publication of The Leonard Hill Technical Group



Protecting the world's beer supply: Terra-Sytam being applied by the special Murphy Lances.



Always Ahead of Insects

Insects have proved to be extremely tenacious enemies to combat, capable of adapting themselves fairly quickly to new conditions. Within a few years of applying a new product which gives effective control of the pests, they develop resistant strains. And so the battle continues. But what does this mean to world agriculture?

It means that large numbers of highly qualified scientists must keep up incessantly their search for new products in order to maintain at all times a commanding lead over the insects. A major part in this work is played by the research scientists of Farbenfabriken Bayer, led by Dr. Gerhard Schrader the discoverer of Parathion. His research initiated a series of developments at Farbenfabriken Bayer, which resulted in farmers all over the world being supplied with exceptionally effective insecticides (TEPP, HETP, Ompa [Schradan], Sulfatep, Methylparathion, Systox, Metasystox, Chlorthion, Dipterex, Gusathion).

FARBENFABRIKEN BAYER AG
LEVERKUSEN / GERMANY

Agencies in all countries of the world.

Editorial Comment

Fertilisers and civilisation

THE STEADY INCREASE in the use of artificial fertilisers is no doubt largely due to the lack of stable manure. Between 1939 and 1956, tractors in use in British farms rose from 60,000 to 436,000, whilst farm horses declined from 1,084,000 to 147,000. Although Britain leads the world in farm mechanisation, similar changes have been taking place in all the highly developed, industrialised countries and, for that reason, such countries take most of the fertiliser produced. Consumption in the under-developed countries is in most cases negligible.

Thus, at the end of the war in 1946, when production was only 6½ million tons of nutrients, the highly developed countries used four-fifths of the total. In 1957, with production at 21 million tons, these countries still used four-fifths, although their agricultural lands are only a little more than one-third of the world total.

It will be agreed that modern civilisation, in which all countries today expect to share the benefits, is based either on its agricultural efficiency, or on the capacity of a country to purchase food abroad, or both. The more food each land worker can produce, the more workers are released to make the components which constitute modern civilisation. If every active member of a community is fully engaged in growing his own and his dependents' food, then the standard of living in that country can only be that of the Stone Age.

In Great Britain today only about half a million persons actually work on the land. Others are connected with the land in that they produce farm machinery, fertilisers and so on, but the full total is probably within one million. These workers produce 60% of the food requirements of the country, enough for 30 million persons. These last include non-workers, of course, young and old, but the majority are capable of producing the commodities of civilisation. This high outturn of food per land worker is possible in Britain because of her reliable climate, good soil, modern farming methods, a very high degree of mechanisation, the liberal use of chemical fertilisers and the increasing application of agricultural chemicals for pest and weed control.

Great Britain still has to purchase food for the balance of her population of 20 million, and this is done largely by exporting manufactured goods to world markets.

By way of contrast and as an example of conditions in an under-developed country, India may be cited. Here, most of the people work on the land, generally without machinery or fertilisers. The climate is such that the exposed soil is burnt out and impoverished at an alarming rate. The result of these conditions is low cropping and a low standard of living. The first need is to raise the output per land worker and the simplest way to do this is by the application of fertilisers. Mechanisation would inevitably follow and by bringing more lands under cultivation, in the short periods of rainy weather, increase the common wealth of the people.

Fertilisers and manures

IT SEEMS a far cry to the '30s, when certain enthusiasts in Britain were urging the use of composts and organic manures to the exclusion of chemical fertilisers. But since then the horse has been disappearing from the road and the farm, and stable manure has ceased to be plentiful. To collect bulky green vegetation for composts demands much labour, and its use amounts to the robbing of Peter to pay Paul. It is one thing to make a compost heap in the garden, but another matter to expand the process to suit the farm or the plantation. In any case, experiments with fertilisers, starting at Broadbalk Field, Rothamsted in 1843, and repeated elsewhere all over the world innumerable times, have conclusively proved the value of chemical manures. Thus, as bigger crops became necessary, the application of artificials was the obvious way to produce them.

In 1939, world production of chemical fertilisers, excluding the U.S.S.R., Eastern Europe and China, totalled almost 9 million metric tons of nutrients (N, P_2O_5 and K_2O_5), amounting to perhaps three times that tonnage in actual fertiliser. At the end of the war, in 1946, production had fallen to 6½ million tons of nutrients, but it has since steadily risen, until in 1957 it was about 21 million tons. Of this total, about one-third comprised nitrogen, one-third phosphoric acid and one-third potash.

Well over half the tonnage is produced in Europe, and almost one-third in North America. Most of the balance is made, and used, in Japan.

About 75% of the phosphoric acid is produced in the form of superphosphate, and 15% as basic slag; the rest is obtained as ground rock phosphate. Potash is supplied mainly as the chloride and not more than 10% in other forms. It is of interest to record that only 33% of the nitrogen fertiliser is as sulphate of ammonia, for there are complications arising from the continued use of this form of nitrogen, in that lime is leached from the soil. Ammonium nitrate constitutes over 25% of world production, and nitrogen 'solutions'

(mostly anhydrous ammonia or aqua ammonia) account for 17%. The rest consists of calcium and sodium nitrates, cyanamide and ammonium phosphate.

These and many other facts of great importance to the agriculturist are put out in the Annual Review of World Production and Consumption of Fertilisers, 1957, issued by FAO. Figures relating to the U.S.S.R., Eastern Europe and China are not included in the Review.

Two countries

THE USE of fertilisers on food crops is very small in Indonesia. Statistics established in 1956* indicated a total use of 7,000 metric tons of commercial phosphoric acid (P_2O_5) and 22,000 tons of nitrogen (N). Japan, with about the same population – 85 million people – consumed 358,000 tons of phosphoric acid and 609,000 tons of nitrogen in the same year.

Fertiliser consumption figures indicate that the quantities used only permit fertilisation of a very small fraction of the rice crop of Indonesia. Rice is the main food crop in both countries: Japan has 3 million ha. under rice, Indonesia 6.5 million ha. Yields in the two countries very clearly reflect the difference in fertilisation: Indonesia produces an average of 1,800 kg. of paddy per ha., Japan 4,800 kg.

What is true for rice applies to almost all crops in the country. FAO is now assisting the Indonesian Government in promoting increased and better use of fertilisers and has, therefore, started a series of programmes, including soil surveys and fertiliser experimentation with a variety of important food crops.

Moly for groundnuts

Dr. NEWTON, of FAO, a Canadian, together with Mr. Anwar Saïd, of the Agricultural Research Institute, Bogor, Indonesia, carried out experiments with groundnuts to study the effects of trace elements and other nutrients, not commonly used as fertilisers, in addition to those commonly used on legumes, such as calcium, phosphorus and potassium.

The beneficial effects of mixtures containing magnesium, copper, boron, zinc and molybdenum compounds was shown by the markedly greener colour of the foliage, which became evident about one month after the planting, and by the increased growth which followed. A test method in which all five elements together, compared with removal of one, two, three, four at a time, was applied. After 8 weeks, it was observed that the 32 plots that did not receive molybdenum were somewhat yellow or less green than the 56 adjacent plots to which this element was applied.

It is evident already that the severely leached soils, such as weathered clayey latosols, which are common in many tropical areas, are deficient in molybdenum. Both nodulation and nitrogen accretion of groundnuts were improved by application of this element, and it is reasonable to expect that other legumes will respond similarly. Yield increases varied between 18 and 25%.

The molybdenum was applied at the rate of 1 lb. per acre of sodium molybdate. In practice molybdic oxide, mixed with superphosphate, will be used. If further tests prove conclusive it is expected that the production of legumes in many tropical countries can be considerably increased by application of molybdic oxide with superphosphate.

China pots

THE AMBITIOUS plans for the improvement of the health of the people of China are forging ahead, for according to a recent article by Prof. Brian Malgraith in the *New Scientist*, the Chinese are liquidating their disease problems.

Of particular interest to farmers and market gardeners is the method now used for the utilisation of night-soil. The use of such manure in Chinese market gardens was formerly a most unsavoury practice and a major factor in the dissemination of diseases of the bowel, for which China was then notorious.

According to the article, 'visitors to the country cannot fail to be impressed with the early morning parade of decorated family pots'. The contents are poured into communal containers which are sealed, when full, and then left for the appropriate time until the faeces are safe for use on the fields.

The success of this organised collection of night-soil is assured by paying the family for it *pro rata* – so many cents per person per day, according to age. It is a fair commentary that most of the valuable waste products of towns and cities in Europe and America are carried away by the rivers to the sea and are lost completely to agriculture.

In praise of the potato

THE ORIGINAL home of the wild potato is said to be either Peru or Chile, where it grows wild on the cool plateaux high up in the Andes. How it was introduced to other countries is, however, by no means certain. Little reliance is now placed, for instance, on the claim that the potato was introduced into Europe from Virginia by Sir Walter Raleigh in 1585, since it is believed that the potato was introduced to North America and Australia from Europe and not direct from South America. Again, the potato that was brought to Europe by Sir John Hawkins in 1565 is now thought to have been the 'sweet potato', *Ipomoea batatas*, and not the ordinary potato, *Solanum tuberosum*.

Nowadays the potato is widely cultivated throughout Europe and in North America and it forms an important part of the average diet, especially in Europe.

* 'FAO Annual Review of World Production and Consumption of Fertilisers 1956'

Considered as a provider of body fuel, through starch, and avoided by those anxious not to acquire extra inches, it is not always recognised that the potato contains other nutritious substances, including the vitamins B_1, B_2 and C, and calcium, iron and proteins. The amount of vitamin C declines with storage. For the first months after harvesting the average vitamin C content is as much as about 25 mg. per 100 g. of potatoes.

There has recently been a tendency to extend potato cultivation. Although not ordinarily a crop for warm regions, there are undoubtedly areas in the uplands of some such countries where the temperature, rainfall and soil conditions would be suitable. This would lead to a more varied diet in these countries, reduce the risk of food scarcity owing to bad harvests of other crops and have the advantage of an additional crop in the rotation, so increasing the productivity of the soil. It would, therefore, seem beneficial that the potato should take its place beside other crops, such as rice, maize and sago. [See p. 333.]

Mass-produced hybrids

TEDIOUS METHODS of hand-pollination in greenhouses have hitherto been used for crossing different strains of cotton. Now, according to the U.S. Department of Agriculture, some strains of cotton can be made male-sterile by spraying the plants in the field with new agricultural chemicals called 'gametocides'. Thereafter selected pollen from one or more high-yielding strains can be broadcast over the crop.

Improving nutrient sprays

THE ADDITION of glycerine to nutrient sprays apparently increases the absorption of phosphorus, potassium and other minerals by the plant. Recent work at Michigan State University indicates that only a small part of the nutrient needs of crops can be absorbed from sprays by the leaves, stems, bark and fruit, but that rate and amount of absorption can be increased by the addition of glycerine and sugar to the spray.

Efficiency of uptake varies with the species. Other influencing factors are age and vigour of the plant, time of day, temperature, humidity and spray content. Properly timed sprays can increase sugar content of beets, improve set of cotton bolls, increase yield of cabbage and crops where low soil temperatures are not favourable to nutrient uptake by roots.

An astonishing claim

THERE IS an increasing awareness of the importance of the minor plant nutrients in agriculture. From South Africa comes news that many maize fields in the Union need zinc, and where the deficiency exists, it has been found that *the application of 10 to 15 lb. of zinc sulphate per acre increases yields threefold.*

It is important to note, however, that this result was not obtained by means of nutrient sprays, but by the direct application of the zinc sulphate to the soil at the time of planting. We wonder whether foliar spraying would have been equally effective if glycerine had been added to the sprayed chemical to improve its absorption by the plant.

The credit for this discovery must go to Dr. N. J. Viljoen, who was one of the first to appreciate the significance of the 'yellowing' and stunting of maize in the Transvaal.

Prevention and cure

WE HAVE been much impressed by the tremendous expansion in what may be described as the curative side of agriculture – the new science of crop protection. Progress has been so rapid that it is not only impossible to keep pace with recent developments in this new science, but it is also difficult to remember the common, proprietary and scientific names for the host of new chemical products and formulations now appearing on the market as insecticides, acaricides, nematicides, fungicides, fumigants, sterilants, herbicides, repellents and rodenticides.

On the protective side, the position is not so dynamic. We refer to the science of crop nutrition which, in the last 50 years, has developed from a consideration of the use of a single nutrient, N or P or K, applied alone, to the necessity for their application in the form of complete NPK mixtures. Today, we now have the confused science of plant nutrition, resulting from the discovery of the nebulous but equally important role played by the micro-nutrients and the growth promoters or plant stimulators. We are only on the threshold of a vast new science involving the interactions of the various elements, the essential role of water in metabolic processes and the part played by the hormones and the new plant stimulators. The planter, the farmer, and the horticulturist are left to carry on with empirical applications of the major fertilisers and even the more knowledgeable treat the use of trace elements in much the same way as they add a pinch of pepper and salt to their food.

The probable explanation for this unbalance in agricultural advances lies in the lack of effective competition in the fertiliser industry and the fierce competition in the field of crop protection. This is reflected in the advertising columns of the January issue of WORLD CROPS; there were 14 advertisements for crop-protecting chemicals and 10 for spraying equipment; there was one advertisement for manganese, one for a seaweed concentrate and one for a book on the efficient use of fertilisers but none at all for the major elements of plant nutrition which today appear to be taken for granted. We consider there is still a tremendous field, particularly in the under-developed countries, for the intelligent application of the various

plant nutrients, now known to be essential for optimum growth. We feel that the layman needs to be educated in the essentials of recent advances in the science of plant nutrition, both in the editorial as well as in the advertising columns of WORLD CROPS. Every advertisement should, we consider, tell a story to the world of agriculture.

Cost of corruption

IN THE course of our recent visit to the Seychelles, our ship was placed in quarantine all because of one case of smallpox. It is common knowledge that false certificates of vaccination could be obtained even though in Bombay alone there were 238 cases of smallpox. A medical certificate was required on embarkation, but a single false certificate of vaccination, paid for in a small bribe of say Rs. 10, could be the direct cause of the loss of many thousands of rupees and of considerable inconvenience to several hundred passengers and their friends, while the ship ' contacts ' and lightermen working the cargo had to be placed in quarantine and kept in idleness for a period of 14 days.

This is a simple and straightforward example of the high cost of corruption. Corruption may take many forms and may be far reaching in its economic consequences ; it may be so widespread as to be practised, consciously or unconsciously, by almost every citizen – the exceptions, perhaps, being the holy men, who have cast off every desire or want. It may take the obvious form of simple or straightforward bribery, or of favours received or given, or of malpractices in the conduct of work or business ; it can permeate a department of government, right through from top to bottom. It may take the form of nepotism or favouritism in the matter of appointments or jobs, or it may take the form of political interference, both of which can have far-reaching consequences in the conduct of affairs.

An interesting example in agriculture is to be found in the buying and selling of copra in many tropical countries, where both buyer and the seller are so often guilty of anti-social acts such as, on the one hand, the use of false scales or weights, and on the other the deliberate inclusion of water in the product. Where these practices have become accepted by long custom and mutual agreement, the product, as exported, will inevitably be of very poor quality indeed, the international reputation of the produce of that country will suffer, and, in the case of large countries, the resulting invisible loss in earnings of foreign exchange may run into millions of rupees per annum.

We would hasten to add – so that there shall be no misunderstanding – that the quality of Seychelles copra is, indeed, of a very high standard and this is recognised in the high premium it can command, but in many countries the position is not so satisfactory and this will inevitably place these countries in a position of economic difficulty if a serious recession in world trade were to develop.

It was freely predicted that when self-government was granted to a certain country (which shall be nameless) that the new government would be wrecked on the rocks of corruption . . . and we have, indeed, seen this happen. It is true that corrupt citizens are to be found in all countries and among all peoples, but when the body politic is so thoroughly corrupted that the social disease affects every limb, sinew and organ of the nation, the end is not far off.

The majority of the newly-self-governing nations were handed over administrative machines in good running order, with their finances in sound condition. Today these countries are running into serious financial difficulties and their long-term plans of economic development are threatened because of the lack of foreign exchange. In desperation they appeal for aid from other countries, and today we have the unsavoury spectacle of great nations competing one with the other to give financial assistance with visible or invisible strings attached, whereas what is needed is the cleansing of the Augean stables and a much higher standard of citizenship in the countries which are now meeting the high cost of corruption.

. . . And the cure ? The cure is a drastic one – as drastic as the cure for cancer. During the war the Japanese were faced with the problem of the Black Market in foodstuffs in the city of Singapore. They acted with characteristic thoroughness – the heads of several offenders were stuck on poles and placed at the roundabout of a busy road junction. The Black Market at once ceased to function!

We do not suggest that bribery and corruption should be made a capital offence, but we consider that where it threatens the economic welfare of the state, it is, indeed, treason and should be treated as such with total or partial loss of civil and social rights, according to circumstances and degree. The punishment should be made to fit the crime.

Whither Ceylon?

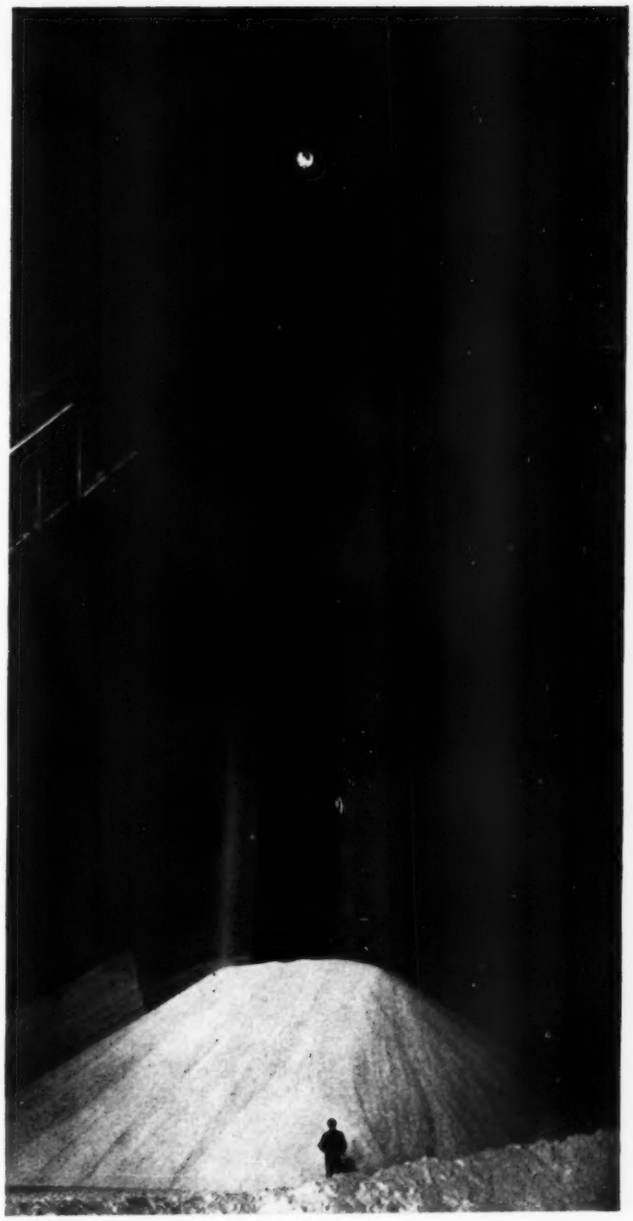
ACCORDING TO a recent report in the *Daily Telegraph* Mr. Philip Gunawardene, Ceylon's Minister for Food and Agriculture, announced that all plantations would be nationalised within five to ten years, yet in a statement issued in May, the Government in which he is a cabinet minister said that there would be no nationalisation of foreign-owned investments in Ceylon for the next ten years.

We wonder whether this doctrinaire idea is really in the best interests of Ceylon. Nationalisation of agriculture has not been a success anywhere in the world, not even in Russia where millions died of starvation. The British Labour party officially discarded nationalisation of agriculture in a recent statement of policy.

A Complete Fertiliser-I

H. L. RICHARDSON, D.I.C., M.SC., PH.D.
(*Imperial Chemical Industries Ltd.*)

In many parts of the world the importance of artificial fertilisers is still not accepted, either because of a lack of understanding or because of the innate conservatism of the farmer. Because this article explains the principles of a correct manuring in such simple terms, it is a valuable contribution to world agriculture, which should have far-reaching consequences



Inside a fertiliser silo
Fertiliser is delivered through a hole in the roof and the mechanical arm is used to spread it over the floor
Photo: I.C.I. Ltd.

BY general custom the name of 'complete' fertiliser is given to mixtures or compounds that contain all three of the 'major' plant foods, nitrogen, phosphate and potash, which are usually represented by their chemical symbols, N, P and K. Such mixtures provide all that the ordinary crop is likely to need when grown in ordinary soils, so that it is fair to call them 'complete'; but from the point of view of over-all plant nutrition, or having regard to the deficiencies existing in some less common soils, an NPK mixture may still be incomplete.

Studies by plant physiologists and agricultural research workers have shown that when plants are grown without soil they require a very wide range of chemical elements, even though some may only be needed in minute traces. The name of 'trace' or 'minor' element has therefore been given to most of the essential elements outside the NPK trinity, but none of them is minor in the sense of being unimportant, and some of them are required by plants in quantities nearly as large as those of the major elements.

The essential nutrients

If we regard all those elements that are required in order to build a healthy crop as plant nutrients, they include, in the first place, carbon, oxygen and hydrogen. These are the chief constituents of organic matter; the plant gets them from carbon dioxide in the air and from water.

Next come nitrogen and potassium, which occur in dried plant materials to the extent of from about 0.5% to 5%, and phosphorus, of which a smaller percentage is present in the plant, but which is still required in considerable quantities. These elements are taken up from the soil in the form of soluble compounds in solution; they are present in practically all soils, but the quantities available may not be sufficient for a large crop.

Also found in fair quantities in plants, and essential for growth, are calcium, magnesium and sulphur. These occur in most soils in sufficient quantities to give normal crops, but they are occasionally deficient. Calcium is likely to be low in acid soils; it is supplied when such soils are limed.

Then comes a group of essential elements, mainly metals, which are present in plant tissues in much smaller quantities that are often measured in parts per million. These include iron, manganese, zinc, copper, boron and molybdenum. Because the plant requires so little of these elements, most soils have an ample supply, but occasionally a deficiency may occur. A soil can sometimes contain the element in a form not available to plant roots. This is particularly liable to happen with the metals mentioned above if an acid soil is limed too heavily.

Like the major elements, the minor or trace elements can only enter the roots of a crop as a dilute solution of some soluble salt. This is worth

Marginal and inter-veinal chlorosis in young rubber

emphasising because it implies that even if plant nutrients are supplied in the form of organic manures the complex organic compounds have to be broken right down to soluble salts before crops can use them. It is all the same to the plant, whether its nutrients come originally from inorganic or organic materials, so long as all the required nutrients are present.

Finally, there are three elements – sodium, chlorine and silicon – which are generally found in plants, but which do not appear to be essential for their growth, except that beets and some other root crops can benefit from a dressing of a sodium compound, including common salt, if the supply of potassium is on the low side.

Deficiency symptoms

When an essential plant food is lacking the plant will show not only stunted growth, but definite symptoms which vary with the nutrient and the degree of deficiency. Thus a poor supply of nitrogen leads to rather small, yellowish-green leaves; a deficiency of potash causes browning and withering along the leaf edges; magnesium deficiency usually gives a rather striking pattern of bright yellow leaves with green veins. The exact form of the symptoms may vary from crop to crop and there are several elements whose deficiency symptoms are similar.

Diseases, or other physiological disturbances, can also cause symptoms that may be confused with deficiency effects. Consequently it is unwise to try to diagnose nutrient deficiencies from plant symptoms alone – although with experience these can be a useful guide. The yellowing of leaf colour, which is typical of several nutrient deficiencies, is called ' chlorosis ' and if the deficiency was caused by overliming the term ' lime-induced chlorosis ' is used.

Plant foods in the soil

A highly fertile soil contains a sufficient quantity of all the elements essential for plant growth in forms readily available to the roots. Thus a really fertile soil does not need any manure or fertiliser, at least as far as the present crop is concerned. However, long-continued cropping without manuring will eventually deplete the reserves of available plant food in the most fertile soil, and deficiencies will begin to show their effects. In order to prevent this happening, and to maintain a high level of crop production, even fertile soils are often manured.

Highly fertile soils are rare. Most natural soils are moderate or low in fertility and – either when first cultivated or after a few years' cropping – they suffer from deficiencies of one or more plant nutrients. As already mentioned, the commonest deficiencies are those of the major nutrients, nitrogen, phosphate and potash, which is why NPK fertilisers are most widely used, and why the three together are usually called a ' complete ' fertiliser.

Here we should point out that the question of whether there is a sufficiency or deficiency of a plant food in the soil is a relative one. Out of the total quantity of a chemical element that is present only a small proportion may be available to plants; different crops vary in their ability to extract plant nutrients from the soil, and the quantity of plant food required varies not only between different kinds of crop, but even with the same crop under different conditions.

Limiting factors

Thus in a dry region without irrigation, moisture supply is the factor mainly limiting plant growth; the small plants that result do not need large amounts of plant food and a soil which is only moderately well supplied with available nutrients can only produce crops as large as the water supply will permit.

If the same soil is irrigated, so that moisture is no longer a limiting factor, then much larger crops are possible, but they will require much larger quantities of plant food. With irrigation it may be found that a soil which previously had seemed adequate is now, in fact, deficient in one or more nutrients and these will have to be supplied, in the form of fertilisers, in order to produce large crops. Indeed, it is very generally observed that crops become more responsive to fertilisers – especially nitrogenous ones – when they are irrigated, and, by the same token, heavy applications of fertilisers may be required if the farmer, and the community, are to get full value from the money spent on irrigation.

Similar considerations apply to soils that have an ample natural moisture supply but are severely deficient in one plant nutrient – say phosphate. Crop production being limited by this deficiency, the supply of the other nutrients may appear adequate and there may be no response, for example, to nitrogen. Once the phosphate deficiency is cured by using phosphatic fertilisers, then larger crops are possible, which may require more of other nutrients than the soil is able to supply – and it will then be found that there is a response, say, to nitrogen, which can profitably be used to enhance the effect of the phosphate.

Another factor that is important in this way is plant number, controlled by the spacing between and within rows. Where plants are widely spaced, and the number per acre is small, they

may be able to get all the nutrients they need from the relatively large amount of soil available to each plant. If a closer spacing is used, so that there are more plants per acre, with less soil to each plant, then the soil may not be able to supply all the nutrients which the crop needs and fertilising becomes both necessary and beneficial. It is frequently found that closer planting brings little improvement in crop yield unless more fertilisers are applied, whilst fertilisers may not secure much response without closer planting; the two together may secure much greater crop production than either separately.

Yet another matter that often has an important influence on the response to fertilisers is crop variety. Certain varieties are less able than others to extract nutrients from the soil and therefore need heavier manuring; with this manuring they may give much heavier yields than other varieties would be capable of. Particularly with cereals and sugar-cane the effect of lodging is important. Some varieties easily become lodged when grown in very fertile soils or when heavily fertilised, especially with nitrogen, and thus it is only safe to give them light dressings of fertiliser. Other varieties which resist lodging are able to respond to much heavier fertiliser dressings and, of course, to reach much higher yield levels. Plant breeders have not always paid enough attention to this, but as a working rule it can be said that heavy fertilising is best used on varieties selected for their good performance in highly fertile soils.

Fertiliser requirements

Evidently the question of the available nutrient supply in a soil, and hence of its fertiliser requirements, is an extremely complex one, which depends not only on the soil, but on the climate, the crop and many other factors. For this reason chemical tests done on a small sample of soil can only give a very approximate indication of fertiliser needs and the results may actually be misleading unless they are combined with accurate field experiments and a great deal of local knowledge. Consequently, no attempt will be made here to indicate what manuring should be used with different crops on different soils.

Properly designed field experiments are the only satisfactory method of estimating fertiliser responses and requirements. Such experiments are not easy or cheap to do and considerable numbers are required in order to give reliable general indications. A well-planned field experiment programme, however, will give reliable information about fertiliser needs and effects that can be obtained in no other way.[1]

Improvement of soil fertility

Between the wars much was said and written about the maintenance of soil fertility; it was generally assumed that a natural soil was a fertile soil and that the aim of using manures and fertilisers should be to prevent that fertility being lost. Today we are becoming conscious of a new aim: the *improvement* of soil fertility, not just its maintenance. We are realising more and more that natural soils may be infertile ones, or may have such small reserves of fertility that a few years of cultivation, without manure, will deplete them; and we are also realising the immense powers of raising soil fertility which modern agricultural methods give us.

Thus the average levels of crop yields in Western Europe or in Japan[2] today are much above those of the past, and also much above those of countries having less intensive or more traditional farming methods. The high yields cannot be attributed to any one cause, but to the combined operation of all the factors that play a part in modern farming, of which – on the soil fertility side – heavy fertiliser usage has a major role to perform. Improved varieties, mechanisation, irrigation, the control of weeds, pests and diseases, the introduction of temporary leys, and the use of bulky local manures or of mulches, are all important, but they could not exert their full effects without a plentiful supply of plant nutrients from chemical fertilisers.

High though yields are in the intensively farmed countries, they have by no means reached their limit, and the yields already obtained in these countries are a measure of the leeway still to be made up by most of the world.

REFERENCES

1. Richardson, H. L.: *Outlook on Agriculture*, 1956, **1**, 87.
2. Richardson, H. L.: *World Crops*, 1957, **9**, 374.

Part II will appear in the next issue.

Variety and manurial trial on sorghum There were two rows for each variety. The two inner rows were unmanured; the two outer rows received sulphate of ammonia and superphosphate

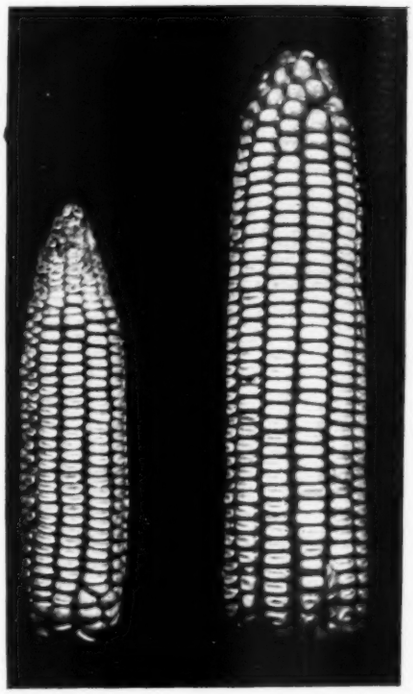
Manurial experiment on sorghum Left: Unmanured plot Right: Manured plot Application per acre: 12 tons dung, 100 lb. sulphate of ammonia, and 50 lb. superphosphate

Potash Manuring

An Essential Factor in Agricultural Production

DR. FRANZ GRUNEBERG,
(Dip. Agr. Justus - Liebig University, Giessen)

The use of fertilisers in world agriculture has increased considerably since the conclusion of World War II. Expressed as K_2O, 3.5 million metric tons of potash fertilisers were used during the years 1948–1951, while in the year 1954 consumption reached 6 million metric tons and in 1957 as much as 8.1 million metric tons. These figures clearly show what importance is attached to the use of the potash fertilisers.

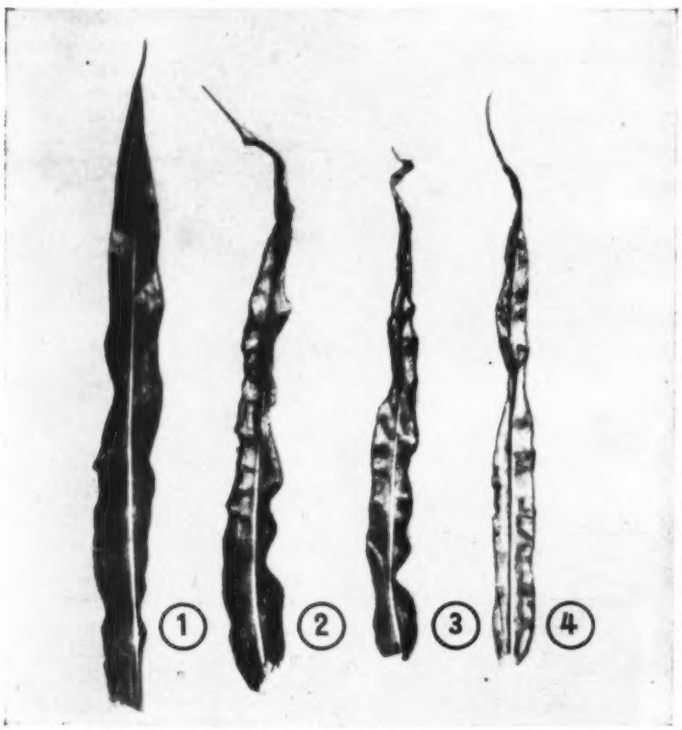


POTASSIUM is the chemical element which constitutes the largest proportion of plant ash. Many scientists have tried to elucidate its role in the plant and all over the world they are still trying to solve certain unexplained problems of its action. Although there are no known organic compounds with potassium as an integral component – as are nitrogen and sulphur in the proteins, phosphorus in the nucleo-proteins, and magnesium in the plant-colouring substance chlorophyll – potassium, nevertheless, plays an important part as a catalyst in the metabolism of the plant. In the living plant, potassium is to be found wherever high-energy transformations take place. Its presence makes possible the formation of sugar from simple carbohydrate compounds and the conversion of sugar into starch and other carbohydrates of high molecular weight.

Potassium is also concerned in the formation and neutralisation of organic acids, and, by developing a balanced proportion of sugars and acids, it promotes the flavour and quality of many fruits. Potassium plays an essential part in the transportation of sugars from the leaves, where they are synthesised, to the organs in which the sugars are consumed or stored. The formation of proteins, according to some views, is rendered possible by potassium serving as a catalyst in the reduction of nitrates. It is also recorded as a constituent of enzyme mixtures.

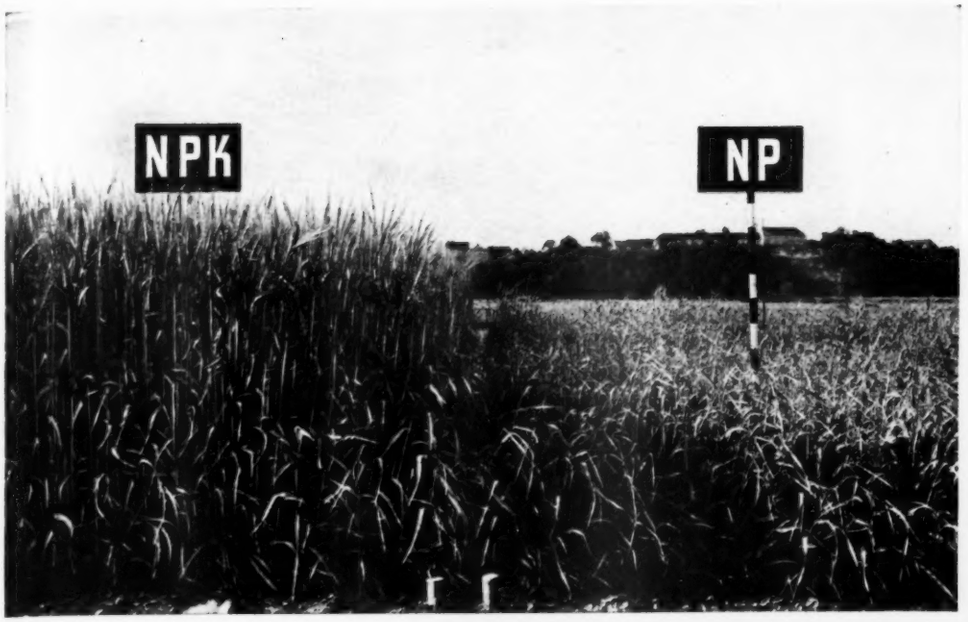
Of not inconsiderable importance in the vital processes of the plant is the part played by potassium in its water economy as the opposite to calcium. Whilst calcium promotes the elimination of water from the plant, potassium promotes the turgidity of the plant cells and thereby maintains the internal pressure of the plant tissue. Conversely, plants deficient in potassium tend to wilt.

Since potassium occurs only in the state of solution or, as is maintained by some workers, very loosely combined with the protein bodies in the plant, it is very easily mobile in the sap stream. When the supply of potassium is insufficient, potassium is removed from the older leaves in order to maintain the functioning of the younger leaves and the developing organs. Thus, in almost all plants, necrosis of the leaf margins of the older leaves is a typical symptom of potash deficiency.



(Above) *Maize cobs showing potash deficiency Left: NP only; cob is stunted and grains small and few Right: NPK; cob with large grains right to the tip*

Left: *Progressive potash deficiency in maize from left to right Symptoms: Curled leaves; yellowing dead leaf margins*



Manurial experiment on barley in Germany
Left: *NPK, yield per acre: grain, 29.9 cwt.; straw, 75.1 cwt.*
Right: *NP, yield per acre: grain, 20.6 cwt.; straw, 47.8 cwt.*

The root systems of barley plants at 57 days
Left: *Without potash*
Right: *With potash*

Photos: Verkaufsgemeinshaft Deutscher Kaliwerke G.M.b.H.

Temperate crops

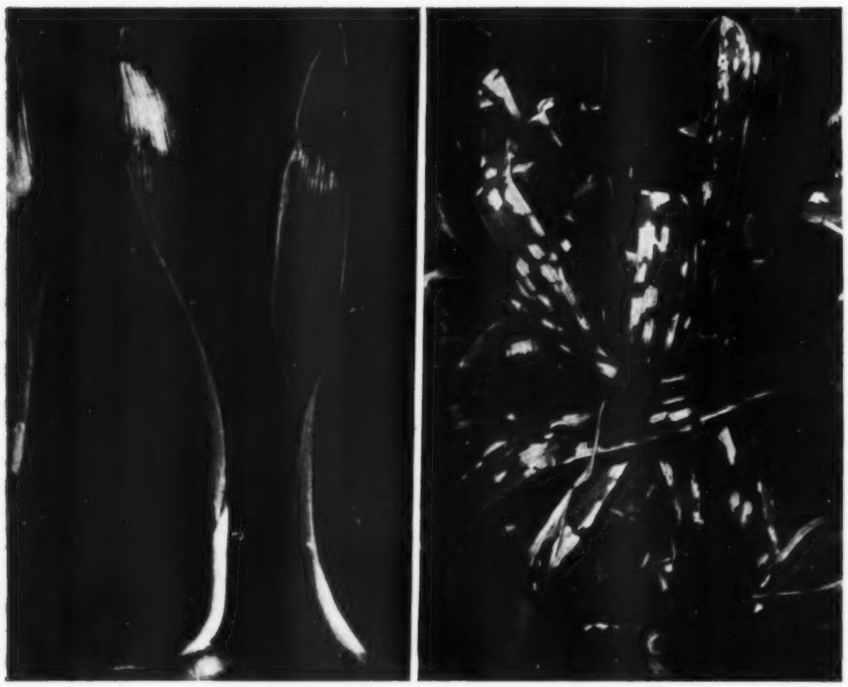
Since potassium is indispensable for the formation of starch, its influence on the yield of the *cereals* is not inconsiderable. As a result of thousands of fertiliser trials, it has been found that with an adequate supply of the other major nutrients, nitrogen and phosphoric acid, 1 kg. of potash increases the yield of grain by 2.8 kg. The influence of potash on the strength of stem of cereal crops is particularly important, as was established by Mulder for European cereals, by Boswell and Parks for maize, and by Noguchi and Sugawara for rice. They all agree that adequate treatment with potash fertilisers increases the strength of the cell-walls in the plant tissues.

With regard to its resistance to lodging, potassium serves as an antagonist to nitrogen. This is explained by the fact that, with excessive doses of nitrogen, the carbohydrates formed with the co-action of the potassium are used up completely for the production of protein. Only a correctly balanced N : K ratio makes it possible for sufficient carbohydrates to be available for the construction of strengthening tissues. The usual dressings of potash to wheat, rye, barley and oats amount to 70–140 lb. K_2O per acre, with a simultaneous application of 35–70 lb. P_2O_5 per acre.

Appreciable increases in yield can not be obtained by any single measure. It is the repletion of all the biological factors that determines the yield of a crop. If the productivity of a plant is improved by breeding, then the germs of productivity, so improved, only become fully effective when, at the same time, adequate nutrition is provided for the higher-yielding plant.

A good example is afforded by *maize*. The introduction of hybrid varieties in the corn belt of the U.S.A. has brought about a considerable increase in yield. This has resulted in increased demands on the reserves of nutrients in the soil, so necessitating greater applications of fertilisers. In the U.S.A., fertiliser dressings of up to 1,000 lb. per acre of the fertiliser mixture, 10 : 10 : 10, or 500 lb. per acre of 0 : 10 : 30 and a nitrogen treatment of 50–60 lb. per acre are now recommended, whereas before the introduction of hybrid maize they managed with far smaller applications. The results of breeding, coupled with the increased use of fertilisers, are again reflected in an increase in the overall average yield from 1,620 lb. per acre before World War II to 2,220 lb. per acre today.

Rice, the cereal which serves as food for the greatest part of the world's population, only gives high yields when the nutritional requirements of this plant are adequately met. The high yields which are obtained in Japan, Italy and Spain, apart from certain climatic factors, can only be



'White Spot Disease' of barley in Japan. This is caused by a deficiency of potash

attributed to the heavy dressings of manures and fertilisers which are given to rice in these countries. In Japan the average dressing consists of 46 lb. per acre N, 16 lb. per acre P_2O_5 and 40 lb. per acre K_2O, in addition to large quantities of organic manures. The average yields of rice in Japan amount to about 3,122 lb. per acre. The crops obtained by the winners of the 'High Yields Contests' are, in fact, 2–3 times greater than the average yields of the country, and an examination of the methods employed by 60 of the winning holdings showed that, on average, 80 lb. per acre N, 79 lb. per acre P_2O_5 and 116 lb. per acre K_2O are given as fertilisers.

Sugar-beet, which produces 5,800–6,700 lb. of sugar per acre with a growing period of 120–180 days, naturally has a very high potash requirement. 180–230 lb. K_2O per acre are regarded as being necessary in those districts which traditionally grow sugar-beet with, in addition, 90–140 lb. of nitrogen and 80–110 lb. P_2O_5 per acre.

The *potato*, being a starch-producing plant, also requires to be carefully nourished with potash fertilisers. It has proved advantageous for this crop to apply 'Patentkali' (potassium-magnesium sulphate), since chloride ions raise the water content of the tuber at the expense of the starch content, and this product, being devoid of chlorides, improves the quality and keeping properties of the tubers. In addition to an adequate treatment with nitrogen and phosphate which can be assessed at 55–90 lb. per acre of each of the two nutrients, 90–180 lb. of potash per acre are regarded as necessary.

Potash must also be on an adequate scale in the fertiliser treatment of *fodder crops*, especially the Leguminosae, in order to obtain the highest possible yields. Since the Leguminosae are able to satisfy their nitrogen requirement from the nitrogen present in the air, by means of the nodule bacteria which live in symbiosis with them, a small application of nitrogen only is necessary as a starter for this group of plants, whilst phosphatic and potassic fertilisers are given in generous quantities to raise the yield and the quality of the fodder, 45–50 lb. P_2O_5 per acre and 90–180 lb. K_2O per acre being recommended.

Fruits of various kinds respond to manurial treatment. In orchard-growing, in particular, where it is a question of regular crops of fruit of high quality, a balanced nutrition of the trees and bushes is the secret of economic success. Nitrogen dressings, regarded as necessary, are 54–90 lb. per acre for pome fruit, 70–90 lb. per acre for stone fruit and 90–140 lb. per acre for bush fruit. The phosphate dressings must amount to 45–80 lb. per acre in the case of pome and stone fruit, and 80–110 lb. per acre for bush fruit. The potash treatment for all kinds of fruit can be assessed at 135–180 lb. per acre. With all varieties of fruit, potassium sulphate and 'Patentkali' have proved particularly valuable as sources of potash since fertilisers, which are devoid of chloride, improve the quality of the fruit and the resistance to diseases in greater measure than potash fertilisers containing chlorides.

Tropical crops

It is not only in Europe and North America that the use of potash fertilisers in agriculture has increased since the end of World War II, but in tropical countries, too, more attention is now being paid to manuring with potash. In countries with development programmes, the manufacture of fertilisers and the instruction of farmers in the correct use of fertilisers are essential features.

In India, for example, the Potash Scheme of the International Potash Institute, in collaboration with Indian authorities and fertiliser firms, has laid out innumerable demonstration experiments on cultivators' fields, in order to give the Indian farmer an opportunity to compare the effect of an NPK treatment, an NP treatment and that of the previous methods of manuring. It has thus been demonstrated that adequate treatment with potash with a simultaneous supply of nitrogen and phosphate considerably increases the productivity of Indian soils. In fertiliser experiments with *rice* in the State of Madras, for instance, an NPK treatment at the rate of 50 lb. per acre of each nutrient gave an increase, on the average, of 437 lb. per acre in comparison with that obtained from an NP treatment with 50 lb. per acre of each nutrient.

Sugar-cane is the crop which gives the most response in weight of cane and in yield of sugar to a potash treatment. Experiments carried out by The South African Sugar Association Experimental Station, Mount Edgecombe, show that by an NK treatment, in which 100 lb. N per acre and 150 lb. K_2O per acre were applied, a yield of 55.4 tons of cane could be produced, whilst only 41.5 tons per acre were harvested on the control plot. A recently published 3 x 3 x 3 experiment from this Station indicates

that profitable yields are assured with dressings of 100 lb. N, P and K per acre.

Balanced fertiliser treatment has proved to be essential for the quality of tropical fruits, particularly for *pineapples*, *citrus* and *bananas*. In the case of pineapple, the nitrogen treatment proves to have the greatest influence on the weight of the plant of the fruit. Treatment with potash increases the acid content of the fruit juice and reduces the proportion of sugar to acid, thereby making the fruit flesh more palatable and attractive. The fertiliser treatment recommended by the Station Centrale des Cultures Fruitières et Tropicales, in French Guinea, consists of 200 lb. N per acre, 75 lb. P_2O_5 per acre and 370 lb. K_2O per acre.

In manuring citrus crops also care must be taken to give an adequate supply of potash fertilisers to the trees, for the potassium ion exerts a considerable influence on the quality of the fruit by virtue of its physiological function. Not only is the quality of the fruit improved by treatment with NPK but the number of fruits per tree and the average weight of the fruits are increased. Since citrus trees are very sensitive to the presence of chlorides in the soil, the use of potassium sulphate, or better still 'Patentkali', is also necessary; the last-mentioned will also prevent an eventual magnesium deficiency.

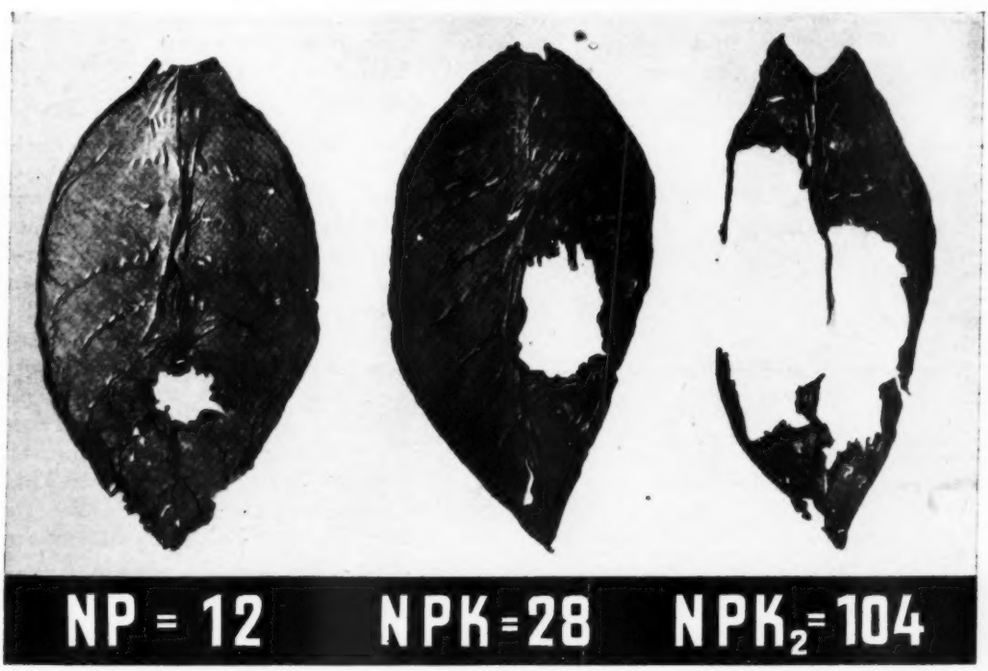
Pélegrin considers that a fertiliser mixture, containing N, P and K with the three nutrients in the proportion 6 : 7 : 28, is necessary for the manuring of bananas. In Guinea, applications of 1.6–2 tons per acre of this fertiliser mixture have proved necessary, whilst in the Cameroons, 0.8 ton per acre was found to be sufficient.

Experience in the U.S.A. shows that *cotton* can only be successfully cultivated with a generous and regular supply of plant nutrients, and potash has a particularly beneficial effect on the quality of the fibre, on resistance to frost, as well as on resistance to pests. Fertiliser experiments with cotton in Brazil, carried out by the Instituto Agronimico do Estado de Sao Paulo, in Campinas, show that with a treatment of 72 lb. N per acre, 108 lb. P_2O_5 per acre and 63 lb. K_2O per acre as muriate of potash, the yield was increased to 621 when the yield of the untreated plot is taken at 100. By applying 'Patentkali' the yield was increased to 635, whilst with NP alone the yield fell to 86.

Another fibre plant for which a potash treatment has proved to be indispensable is *sisal*. This plant makes very high demands on the soil's store of potash. When the potash supply is insufficient, necrotic spots appear at the base of the lower leaves and finally lead to the leaves breaking off; this is generally known as Banding Disease.

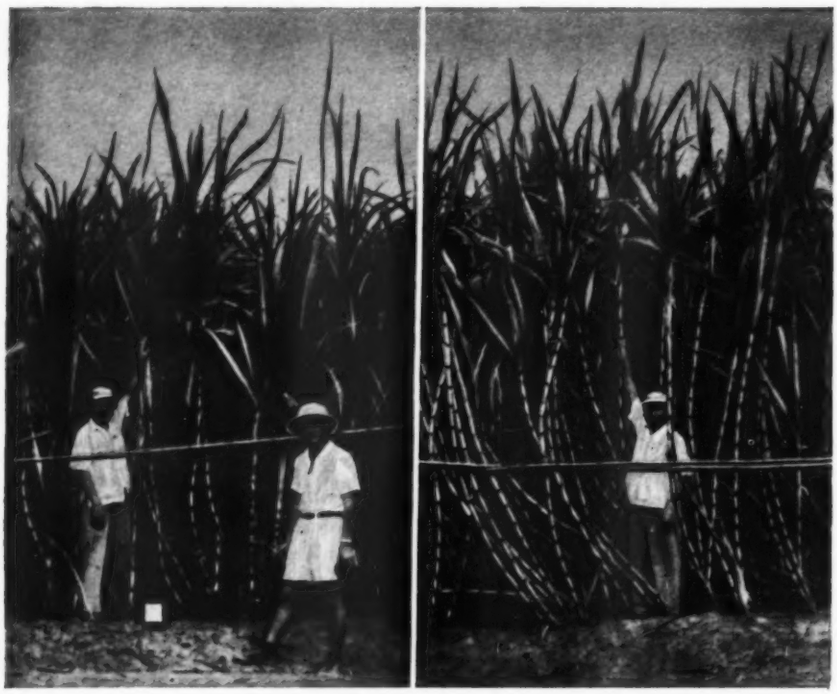
Oil-palms, no matter where grown, have proved very sensitive to lack of potash. In Nigeria, the potash and magnesium treatment is regarded as one of the most important problems in the maintenance of the productivity of oil palm plantations. 'Confluent Orange Spotting', the disease attributable to potash deficiency, and 'Orange Frond Disease', which is caused by magnesium deficiency, are the diseases which occur most frequently. In one experiment, a single application of potash at the rate of 5 cwt. per acre enabled the yield of 30-year old oil-palms to be doubled within 2 years.

Reports are to hand from Ceylon, India and the Ivory Coast, from which it emerges that potassium is the nutrient of which the *coconut palm* is in greatest need. Thus in a 15-year fertiliser trial at the Coconut Research Institute in Ceylon, in which 0.75 lb. K_2O per palm and 1.5 lb. K_2O per palm were applied, the higher application of potash in the last year of the experiment gave a production of 846 lb. copra per acre, whilst the lower dressing gave only 664 lb. copra per acre. The number of nuts which were necessary for the production of the unit weight of copra was less with the higher potash treatment than with the lower additions of potash. Experiments by the Coconut Fertiliser Demonstration Scheme, in India, in 1955, gave an average increase in yield of 10 nuts per palm on the NPK plot in comparison with



Prolonged smouldering which is a sign of good quality

The effect of potash on the quality of tobacco is shown by
Left: *NP only*
Middle: *NPK*
Right: *NPK*$_2$



Manurial experiment on sugar-cane in Formosa Left: *NP only gave* 7,057 *lb. sugar per acre* Right: *NPK gave* 15,332 *lb. sugar per acre*

the control plot. Annual dressings of 0.5–0.75 lb. of nitrogen and phosphoric acid and 1.5 lb. K_2O per palm are recommended.

The fertiliser requirements of *tobacco* has for years been subjected to a thorough examination in Tobacco Research Institutes throughout the world. All the published papers agree that a treatment with potassium sulphate improves the yield of tobacco, both qualitatively and quantitatively. Colour, aroma and combustibility are to a large extent dependent on the quantity and on the nature of the fertilisers applied. An application of 45–225 lb. K_2O per acre is recommended, in addition to applications of 18–54 lb. nitrogen per acre and of 16–32 lb. P_2O_5 per acre.

Manuring with potash has proved necessary for *tea*, especially in Southern India and in Ceylon. In Ceylon, fertiliser experiments showed that by applying 20 and 40 lb. K_2O per acre there was an increase in the yield which in the sixth pruning period reached the level obtained by nitrogenous manuring. In the seventh pruning cycle in these experiments with an application of 40 lb. per acre an increase in the yield of 497 lb. dry matter per acre was obtained, as compared with the plot which did not receive potash.

In *coffee* growing, too, balanced manuring is regarded as essential for satisfactory yields. Recently published papers from Brazil show that the alternate (biennial) bearing of sun-grown (unshaded) coffee bushes can be prevented by adequate applications of mixed fertilisers. At least 4 applications per year, each of 4 oz. per tree, are considered necessary; the fertiliser mixture which is recommended contains the nutrients in the proportion of 13 : 13 : 13.

Last but not least, mention must also be made of *pastures* whose economic value can be considerably increased by manuring. Fertilisers, containing P and K, are recognised as a means for increasing the yield, especially when a fodder is desired which is rich in legumes. The application of potash fertilisers to grassland in Australia has increased within one year from 5,516 long tons to 9,368 long tons of 60% muriate of potash. Coventry Estates, Hamilton, New Zealand, with 100 cows on 120 acres, produced 283 lb. of butter fat per acre. On this holding 2 cwt. of 60% potash salts are applied per acre to grassland, and to lucerne 3 cwt. superphosphate and 2 cwt. of 60% potash salts.

Summary

From the many foregoing examples, it can be seen how potash in association with the other two major nutrients, nitrogen and phosphate, can increase the productivity of agricultural crops throughout the world.

Coming Events

Agricultural Machinery. — There will be a running broadcast on a display of British agricultural machinery and directed to Central Africa by Audrey Russell on 9 September.

Agriculture. – The Budapest Agricultural Exhibition will be held from 12–28 September during the International Viticulture Congress. Information from Hungarian Chamber of Commerce, Budapest, 62, P.O.B. 106.

Pre-packing. – An international exhibition and conference on pre-packing of fresh fruit and vegetables covering all aspects of pre-packing from field to consumer is to be held in London from 7–9 October. It is to be organised by the Ministry of Agriculture on behalf of the European Productivity Agency of OEEC. Enquiries should be addressed to the Produce Pre-packaging Development Association, Agriculture House, Knightsbridge, London, S.W.1.

Weeds and Weed Control. — The Fourth British Weed Conference will take place at Brighton from 3-6 November. Information from the Society of Chemical Industry, Belgrave Square, London.

Seed Production. – A Herbage Seed Production Conference, organised by the National Institute of Agricultural Botany, will take place on 18 November at Cambridge, England.

Cottonseed. – A symposium on 'Cottonseed and its By-products' will be held in Hyderabad from 5–7 December. Discussions will cover the processing and storage of cottonseed, refining of cottonseed oil, hydrogenation, solvent extraction, fundamental studies, by-products, standards, statistics and marketing data. Enquiries to the Director, Regional Research Laboratory, Hyderabad–9, India.

Smithfield Show. – The Smithfield Show and Agricultural Machinery Exhibition will be held this year from 8–12 December.

Organic Irrigation

An introduction to the Gülle System

DR. F. BRÜNNER

(Staatl. Versuchsanstalt für Grünlandwirtschaft und Futterbau, Aulendorf, Germany)

On every stock farm there is a continuous supply of animal manures. In the Gülle system, the dung and the urine are collected, matured, diluted and subsequently applied to the pastures as a liquid manure.

THE effective use of organic manures is an important factor in farming economy, particularly where a large number of animals are carried. The Gülle system of using dung is a method of farming practised in an extensive area around the Alps, particularly in the Allgäu province of Germany, and in parts of Switzerland.

Gülle farming

' Gülle ' is much more than a simple liquid manure; it is a mixture of dung, urine and bedding matured together and diluted with considerable quantities of water.

This method of storing and using dung in water has come about because of the lack of long straw, as in many areas around the Alps grass forms as much as 100% of the land coverage on many farms. For these high pastures a large cattle population is the only answer, but not enough bedding straw is available and without adequate supplies of straw it is impossible to produce good muck, or farmyard manure. It is therefore better to store the dung and urine in a liquid form in a pit.

The arable/pasture ratio was not always the same. About 80 years ago arable lands formed at least one-third of the total, for a certain amount of arable was necessary to earn a livelihood. But as soon as the development of communications allowed a freer exchange of commodities the price of corn fell so much that the profitable cultivation of these steep fields with arable crops was no longer possible. More and more land was laid down to grass until animal husbandry ultimately became the sole form of farming. This development was made possible by the establishment of the hard cheese industry, which made it possible to dispose of all surplus milk produced.

The small quantity of straw now produced is eked out with bedding produced in special ' litter meadows ', with sawdust or any other suitable materials.

With milk and meat as the sole harvest, comparatively small quantities of minerals are taken from the land, *i.e.* smaller by comparison with the production of corn, potatoes or even sugar-beet. The minerals in the grass or fodder appear again in the Gülle or in the muck; it is then put out at the next application to pass once again through the animal to the Gülle pit or the cattle yard. In this way farms which are given over entirely to animal husbandry can, with only a small replacement outlay on artificial fertilisers, put large quantities of plant nutrients back on their fields.

Apart from this small expense on artificial fertilisers, the continual circulation, by means of frequent Gülle applications and short grazing periods, means that the same mineral nutrients can be used two or three times in a single year. Fertilisers applied in the spring Gülle come back again into the Gülle pit after the animals have grazed over the fields once and can again be contributing to pasture production by June, and the process can be repeated again in the autumn.

Mineral content

The mineral content of Gülle can fluctuate, from time to time and from

An installation by Wright Rain Ltd. The materials are cut up and intimately mixed together in the cylindrical tank, and the resulting flurry is pumped up the hillside to the Gülle-Werfer or mobile spray jet.

Table 1

(*a*) Comparative values of urine and dung

(in percentages)

	Dry matter	*Total nitrogen*	*Total phosphorus*	*Total potash*	*Total lime*
Urine ..	5.7	0.60	0.006	1.80	0.09
Dung ..	12.4	0.32	0.19	0.17	0.37

(*b*) Relative amounts of NPK and lime

(ratio based on equal amounts of phosphorus)

	Total nitrogen	*Total phosphorus*	*Total potash*	*Total lime*
Urine	100	1	300	15
Dung	1.7	1	0.9	2.0

one farm to another, within very wide limits. For this reason, opinions on its use and value and on the different ways of employing it vary considerably. Gülle contains dung and urine and litter; the water is added to dilute it. In fact, the nutrient value of the small quantity of litter can be left out of account. What really matters is the relative proportions of dung and urine, because these basic constituents are widely different in their composition.

From Table 1 it can be seen that urine is very rich in nitrogen and potash; dung, on the other hand, contains practically all the phosphorus voided by the animal. These differences explain the wider variations in the analyses of different samples of Gülle, since obviously this depends on the relative proportions of dung and urine in the mixture.

In winter, on most farms, muck is produced from the litters and is stored in a muck heap. Only urine with a slight admixture of dung finds its way into the Gülle pit. The result is a so-called winter Gülle (although it is probably not applied until the spring), which is very rich in nitrogen and potash, but is deficient in phosphorus. Such Gülle, because it lacks the thickening effect of dung and muck, also gives the misleading impression of being very thin and weak. It can, in fact, be very much richer in nitrogen and potash than a thick and apparently rich Gülle containing relatively large amounts of dung, see Table 2.

Dilution

Another important factor is the extent to which the mixture needs to be diluted with water. In order to be able to describe this dilution, a terminology has been devised by which one speaks of '5', '10' or '15' Gülle. The figures are used to denote the extent of dilution, *viz.* 5, 10 or 15 parts of water to one of Gülle. On the basis of the 371 samples taken from the 70 farms, it was found that the overall average water content was three parts water to one of Gülle or, in other words, the average Gülle could be called a '3' Gülle. This is the usual degree of dilution, and it is seldom that it is diluted more than five times, as a dilution of 10 or 15 times can only be made where large quantities of water are available. In general, high dilution, although better, is not essential, for, apart from the availability of water, few farms have Gülle pits large enough to cope with huge quantities of liquid manure.

Gülle is alkaline and the more urine present, the more alkaline is the mixture. From 40 samples taken it showed an average *p*H of 7.6, with a highest figure of 8.8 and a lowest figure of 7.2.

Fertiliser equivalent

On average the amounts of plant nutrients accruing on a farm per large animal per ha. are as follows:

Dry matter, total	1,962 kg.	or 1 ton 18½ cwt.
Nitrogen,	70.4 kg.	or 1 cwt. 42 lb.
Phosphorus,	21.7 kg.	or 47 lb.
Potash,	119 kg.	or 2 cwt. 27 lb.
Lime,	46.9 kg.	or 103 lb.

Table 2

(*a*) Comparison of Gülles

(371 samples from 70 farms)

	Total nitrogen	*Total phosphorus*	*Total potash*	*Total lime*
Gülle in March	0.120	0.012	0.21	0.03
Gülle in May	0.115	0.040	0.24	0.10
Overall average	0.127	0.031	0.22	0.08

(*b*) Relative amounts of NPK and lime

Gülle in March	10	1	17.5	2.5
Gülle in May	2.9	1	6	2.5

These figures are astonishingly high and when it is realised that the carrying capacity of a Gülle farm amounts on average to 1.5 large animals (often even as much as 2.0) per ha., it can be seen what large quantities of nutrients do, in fact, accrue to the farm.

Unfortunately, the phosphorus content is very small and it is essential to correct this deficiency to produce a balanced complete fertiliser. If this phosphorus in the form of superphosphate is spread on the floor of the buildings, there is a reduction of the nitrogen loss experienced there. Although Gülle is rich in potash, an addition is sometimes necessary if the soil is particularly deficient. If the soil lacks potash, then the derived Gülle will also lack potash, for Gülle can contain only the elements that are

Table 3

Comparative temperatures

	Inside pit	*Outside pit*
Average temperature	15.0°C (59°F)	11.1°C (51.9°F)
Average in winter	13.1°C (55.5°F)	8.1°C (14.5°F)
Average for remaining months	16.2°C (61.1°F)	10.8°C (51.4°F)
Lowest recorded temperatures	10.0°C (50.0°F)	2.0°C (35.6°F)

already on the holding. An addition of nitrogen can also be economical if given at the right time, in early spring.

Storage pits

On the Gülle farms of the Allgäu there are two main types of pit for the storage of Gülle: indoor and outdoor. There is still some doubt about the advisability of having an indoor pit owing to the effect on the health of the animals of exhalations rising from the Gülle pit under the building. At one time it was forbidden by law to have an inside pit. The regulation, however, had to be rescinded because of strong opposition from the farmers, who believed that the higher temperature of the inside pit in comparison with the outside pit improved the quality of the resulting Gülle. With the indoor pit there are no loads to carry about, for everything, dung, urine and litter, are pushed down through the hole in the floor.

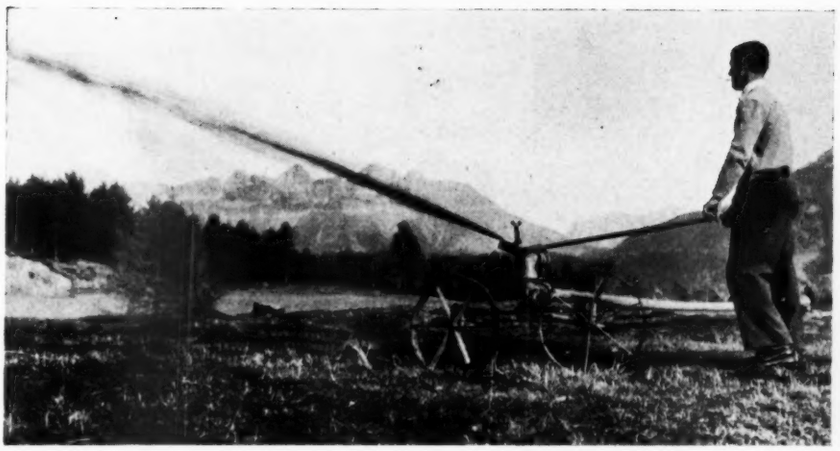
It is possible so to arrange the inside pit that its advantages are retained and its disadvantages eliminated. The hole through which the muck is pushed can be made self-sealing like the goose-neck of a siphon. It is only necessary to replace the wooden floor boards with a concrete deck and fit the hole with a seal to make the storage tank completely airtight, except for a special breather pipe. The inside pit gives better results than the outside pit, which is most apparent in the spring. These different results are to be attributed, not to the differences in mineral content, but to differences in temperature, as shown in Table 3.

Losses during storage

In order to determine the losses which occur during storage, an investigation was carried out during the winter of 1952, the results of which are set out in Tables 4 and 5.

Duration of storage

The benefit to be derived from Gülle farming can vary widely between



Close-up of the mobile spray jet

one farm and another and, indeed, between herds of equal size and the difference can be traced back, not to the nutrient value of the Gülle, but to the skill in its application. The findings are summarised in Table 5. The farms were classified in four groups, according to storage time. Whereas those in Group 1 stored their Gülle for three weeks, those in Group 4 stored it for several months. The effect of these storage times can be seen in the amount of pasture which each farm requires per large animal. For the first three groups there was little difference. If the storage is particularly long, a greater allowance per animal is necessary because the yield of grass diminishes. This is the result, not of more prolonged storage, but is due to the less frequent applications of Gülle. Only three-quarters of the fields in these Group 4 farms were dosed annually; in Group 1 all the fields were treated nearly twice a year.

There thus appears to be a relationship between frequency of dosage and yields. The manures in the Gülle stored only for a short time is put out again quickly and can, in fact be, returned to the Gülle pit even within the growing time. This is so in Allgäu province, where regulated grazing is standard practice. Here the cow is housed for the greater part of the day, she is kept in for 20 out of the 24 hours and only allowed out to graze for two short periods of two hours. Sometimes she is not allowed out at all. On those occasions she is 'in-grassed'; that is, she is fed with fresh machine-cut grass. In this way there is a quick turnover of plant nutrient.

From Table 6 it may be seen that the number of the applications rises and the storage time decreases from Group A to Group D. This is possible because more water is added and also because relatively smaller

Table 5
Effect of storage on yields

Records for 70 farms in 4 groups	*Group 1 Up to 25 days*	*Group 2 26–40 days*	*Group 3 41–55 days*	*Group 4 56 days and more*
Average storage time (days)	22.3	31.3	48.2	119.0
Relative frequency of spreading per year ..	1.7	1.6	1.2	1.74
Dilution	5.6	3.6	3.0	2.9
Area required per large animal (ha.)	0.52	0.52	0.53	0.65
Yield: kg. milk per ha...	4632	4633	4160	3178

Table 4
Changes in composition of Gülle during storage

Date sample was taken	*Dry matter*	*Nitrogen*	*Phosphorus*	*Potash*	*Lime*
5 January	1.4	0.129	0.017	0.37	0.06
21 January	1.3	0.125	0.017	0.36	0.05
31 January	1.2	0.123	0.018	0.36	0.06
7 February	1.1	0.115	0.017	0.36	0.04
15 February	1.1	0.113	0.017	0.36	0.04

amounts of fertiliser are put out at each application. In Group D so much water was added that operations could start again after four weeks. The effect of these more frequent applications shows itself in a decrease in relative pasture requirement per animal with corresponding increases in milk yields. This table shows that the greater frequency of dosage and higher dilution decisively improves yields.

Method of spreading

When Gülle was first used, the material was spread by means of casks, but many steep slopes could not be manured. Where possible, farms used the slope of the land to fill the cask by gravity and to spread the contents through pipes over the fields that lay below the farm buildings. Now suitable pumps have made it possible to treat fields at any level and increased additions of water are possible without heavy transport.

A further improvement in the spreading resulted when the 'Güllewerfer' (Gülle-thrower) replaced the simple nozzle at the end of the pipeline. It is now possible to spread Gülle wearing ordinary clothes, whereas the old hand nozzle bespattered the operator with this offensive material.

Pasture management and costs

It has been shown that with frequent applications the same minerals can be used a second time in the same growing period, but grazing needs to be properly managed. In Allgäu, grazing is permitted for two hours twice daily during the spring flush; in late autumn, when growth is relatively small, the cows stay longer in the field. This short grazing period and strip grazing brings the greater part of the manure put out with the Gülle back into the pit.

The effect on milk yield can be seen in Table 7. It is apparent that the amount of nitrogen contained in the Gülle falls away with the lengthening of the grazing time. The milk yield per cow is somewhat greater the longer she is allowed to graze, but more time at grass involves higher pasture losses due to trampling, lower return of minerals to the Gülle pit and more rank growth due to dung pats, which, far from promoting, actually lower the grazing capacity of a field. Even these disadvantages are far outweighed by the increased yield of milk per ha.

On the smaller farms it often happens that through unfavourable weather the cows are kept stalled up and are 'in-grassed'. As a result, more urine and dung fall into the Gülle pit, there is less rank growth and less loss through trampling. In the larger farms, however, where labour has to be paid for or may not be available, short grazing periods are not practicable and maximum milk yields per ha. are not attainable.

Cash value

It has already been pointed out that through the sale of only milk and meat the quantity of plant foods lost from the farm is small, for much the greater part of the minerals either return to the Gülle pit or are made into muck. An average fertiliser balance sheet was made out for the 70 farms investigated. This showed that about 130 kg. net of nitrogen was applied on average per ha. – an amount corresponding to intensive manuring. The quantity of potash so applied was also high; even phosphorus was not low. The bulk of the plant nutrients – 188 DM. worth out of 282 DM. – came from the Gülle. The small amount of muck produced accounted for 54 DM. worth per ha. The artificial fertilisers added accounted for a total of only 40 DM.; expenditure on nitrogen and potash was small and the chief item was the purchase of the phosphorus necessary to turn the Gülle into a complete fertiliser.

Abstract published by permission of Farrow & Sons, Ltd.

Table 6
Relation between frequency and yield

Classification according to frequency of the application	*Group A*	*Group B*	*Group C*	*Group D*
Number of doses per year	0–1.0	1.01	1.51–2.0	>2.01
Average of the group ..	0.7	1.3	1.8	4.4
Dilution	2.9	3.3	3.5	4.4
Accruing Gülle per ha. ..	42.9	73.3	102.1	127.3
Storage time (days) ..	76.9	35.2	30.1	28.0
Pasture requirement per animal	65	56	47	43
Kg. milk per ha. ..	3285	4155	5001	5706

Table 7
Influence of the grazing times on milk yields

Classifications of 70 farms into three groups	*Yearly grazing time in hours*		
	Group X Up to 1300 *hours*	*Group Y* 1301–1500	*Group Z* 1501 *upwards*
Nitrogen in kg. per ha.:			
(1) Spread as Gülle	115.3	93.2	76.3
(2) Spread as muck	27.7	30.6	28.2
Pasture requirement per animal (relative)	0.49	0.54	0.58
Milk per cow in kg.	3236	3217	3344
Milk per ha.	4935	4243	3928

Gas from Manure

The Polish agricultural journal, *Gromada. Rolnik Polski*, reports briefly on an experimental plant for producing domestic gas from cattle manure, to provide gas for 50 farms, designed and built at the Cegielski Works in Poznan. The nutrient content of the resulting manure is improved in the processing.

Liquid Manure

Experimental use of liquid nitrogen from gaswôrk sources for green-crop dressing has been successfully carried out in Scotland by Sir Alexander Kinlock. This material will be used in the coming season at the rate of 400 gal. per acre per cut.

Seaweeds

A Plant Food

H. ROSENAUER
(*Sèvres, France*)

Seaweed, Laminaria digitata, *exposed at low tide*

This is an abstract of a paper read at the International Horticultural Congress at Nice in April this year. Seaweeds contain hormones which encourage root development, and also the chemical elements, present in seawater, which can be applied in liquid form as a foliar nutrient. The author further states that processed seaweed is an excellent soil conditioner and that it improves the water-holding capacity of a soil.

THE effects of the application of seaweed to plant and soil are produced in three separate ways: biologically, catalytically and photosynthetically.

Apart from containing the main chemical elements of nutrition needed by plants – nitrogen, potash, phosphorus, calcium, boron, chlorine, sulphur, copper, cobalt, iron, zinc, manganese, magnesium and molybdenum – seaweed is a complex base-exchanging substance. The contained alginic acid acts as a collector of the various elements and spectral analysis has indicated several dozen to be present, including the above.

Recent research has helped to explain the mechanisms (mostly enzymatic) which condition the quality of a plant. These enzymes depend for their action on the presence of metallic ions, so that a trace element deficiency could upset the functioning of one or more enzyme systems. It can happen that the quantity of the crop will remain high, the quality alone suffering. Conversely, top quality is not always associated with maximum quantity.

Cattle grazing on seaweed on the shores of Loch Eil

The Boyce Institute, of California, has shown that seaweed on decomposition produces plant hormones which have an important effect on root development and healthy growth.

Photosynthetic action

Seaweed produces a favourable medium for the formation of intermediary substances which aid production of the principal constituents of plants.

Organic compounds stimulate the activity of photo - tropic bacteria (probably by acting as hydrogen donors), and seaweed is an excellent culture medium for bacteria. This is important, since as much as 50% of the photosynthesis of the higher plants is by bacterial photosynthesis.

Liquefied seaweed

To enable seaweed to be used more widely and economically, certain problems needed to be solved:

1. The organisation of the harvesting to obtain sufficiently large quantities of different varieties of seaweeds to produce a mixture in biological equilibrium.

2. The treatment of the seaweeds to produce a concentrated, liquid and stable end-product while retaining the properties of living plant.

Qualitative variations are also produced by the addition of extracts of land plants.

The application of this liquefied seaweed has a remarkable effect on the structure of the soil and the contained humic and alginic acids increase the water-holding capacity and produce the necessary crumb structure. This results in better soil aeration and, therefore, an increase in the aerobic bacteria and fungal mycelia. The considerable increase of the surface area assists chemical and biochemical exchange, thus improving fertility.

Aphides, particularly the black and green aphis, rarely attack crops sprayed with liquefied seaweed. Similarly, eelworm appear to avoid fields so treated.

Liquefied seaweed is applied to the leaves as a fine spray. This type of application to the parts of the plant above soil level produces an economy of 80 % of the product used, compared with its application in the conventional manner to the soil, and its action is also more rapid. Liquefied seaweed is non-toxic and non-alkaline and can be applied in any dilution to the soil, but its application as a foliar spray is to be preferred for reasons of economy.

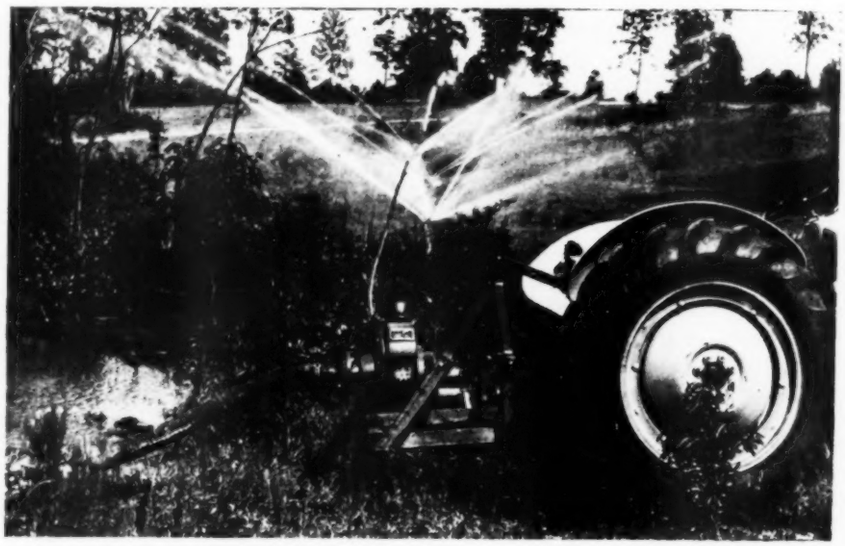
Man-made Rain

Film produced by Aluminium Union Ltd. in sound and colour. 30 mm. Time 20 min.

The film opens with a series of diagrams to illustrate the expressions ' field capacity ' and ' temporary and total wilting point '; it goes on to demonstrate the advantages of man-made rain over ordinary surface irrigation for encouraging steady plant growth by correcting soil moisture deficiencies as they arise. It also shows how alkali problems, common in some areas with surface irrigation, are eliminated by irrigation with man-made rain, which also avoids the leaching of soil nutrients and the problem of waterlogging in the low-lying areas.

The second half of the film shows how aluminium could be used for the advancement of agriculture. Sprinkler irrigation, using aluminium piping, is now being applied to coffee in Brazil, to the hillside vineyards of Germany, to the rolling citrus groves of Mexico, to sugar-beet and fruit orchards in Canada, to alfalfa, maize, cotton, fruit and tobacco in the U.S.A., and to grain and citrus in Israel.

The film was not intended to advertise any particular type of rain-making equipment, but rather to show how effectively water can be delivered to the field through light aluminium piping, irrespective of difficulties of the terrain, and how this water can be distributed to good advantage by means of a sprinkler system, whatever the type of soil. It showed how the levelling and grading of fields, as required for ditch irrigation, are unnecessary, and how hillside irrigation of vineyards and orchards, of tea and coffee estates in a mountainous terrain and of pastures in areas, liable to drought, is now possible. Field ditches, contour drains and concrete flumes are unnecessary, thereby increasing the area available for cultivation, and where the supply of water is limited man-made rain requires 60% less water than ordinary surface irrigation.



The pump is the heart of the irrigation system. Here a Marlowe pump is being operated from the p.t.-o. of a farm tractor

Drought and dry spells during the growing season are an ever-recurring hazard in many parts of the world and in particularly dry years, man-made rain can make all the difference between a good crop and no crop at all. In arid regions, such as Israel, it now makes possible the raising of a crop where otherwise agriculture would be, at best, a hazardous undertaking.

Technical News

Articles in the September issue of some of the other journals of the Leonard Hill Technical Group include the following:

Public Works and Muckshifter.— ' Water Supply – The Construction of Reservoirs and Wells '; ' Belt Conveyance of Spoil ' by A. G. Arend.

Atomics. – ' The Significance of Geneva ' by Sir John Cockroft; ' Nuclear Energy in the Service of Mankind ' by Professor S. Eklund.

Manufacturing Chemist. – ' Wetting Agents for Agricultural Sprays ' – 2 by J. S. Stanley, PH.D.; ' Work Study and Piping Design ' by A. Battersby.

Dairy Engineering. – ' Purity of Water for Use in Dairies ' by D. V. James; ' Preventing Corrosion in the Dairy Industry ' by L. A. G. Johnson.

Food Manufacture. – ' Ultrasonics in Food Manufacture ' by J. S. Smith; ' Research and Glass Containers '.

Paint Manufacture. – ' Aluminium: Versatile Pigment'; 'Epoxide Resins'.

A Trace of Copper

A Little Goes a Long Way

A. V. COOMBS, DIP.AGRIC. (WYE), A.I.C.T.A.
(*British Sulphate of Copper Assoc. Ltd., London*)

How to grow two ears of corn where one grew before is a problem that is with us all the time. How copper can act as a limiting factor in plant growth and productivity is here discussed.

JUST over a century ago, attention was first focused on what we now know as the major plant nutrients – nitrogen, phosphate and potash. It was not until many decades later that it was realised that in addition, a host of other minor or trace nutrients are just as essential to the growth and well-being of plants.

When land was plentiful and the demand for food was not as great as it is at present, only the most fertile soils were cultivated. The war and the increasing world population have necessitated the utilisation of more and more of the less productive lands. The role that traces of copper have to play in raising the fertility of certain soils is only now beginning to manifest itself and much marginal land in many countries which was at one time thought unsuitable for growing crops or maintaining livestock is being converted into rich fertile farm land with the addition, along with other nutrients, of a few shillingsworth of copper sulphate or ' Bluestone.'

World-wide copper deficiency

A classic example comes from *Australia* where areas of the ' Ninety-Mile Desert ' before their transformation from barrenness to fertility, barely carried one sheep per 10 acres. Today, after the application of a few lb. per acre of zinc and copper sulphate, with superphosphate, the Australian authorities claim they are carrying two sheep to each acre and the productive value of the land has risen from 8*s.* to A£7 per acre. It was in Australia too that the need for copper was first observed because grass grew under the overland telegraph line which crosses the continent.

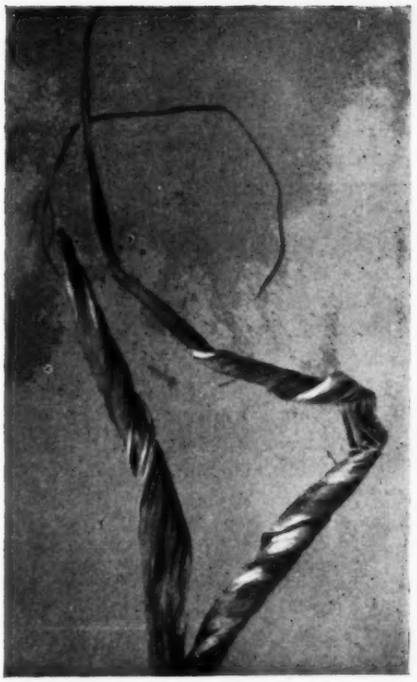
In *Britain* the necessity of bringing under the plough poor marginal land, during and since the war, is beginning to reveal a deficiency of copper which until 1946 had not even been suspected. An inadequate amount of copper in the soil has been traced as the cause of the failure to grow good cereal crops on some of the sandy reclaimed acid heathlands of Norfolk and East Suffolk and also some of the peaty fen soils of Cambridgeshire, the Isle of Ely and Huntingdonshire.

More and more lands, deficient in copper, are being discovered. The application of 30 to 40 lb. copper sulphate per acre applied in the form of a fertiliser before sowing, or spraying the foliage of the cereal plants when they are 6–8 in. high with 12 oz. copper sulphate in 20–100 gal. of water per acre, are two remedial measures which have been adopted with considerable success and have resulted in a big difference in yield at harvest.

Yield increases of 500% are not uncommon on some of the more deficient soils. Soil application has the advantage that it persists for a number of years. Trials laid down 7 years ago are still showing a residual effect. The foliage applications on the other hand have to be given to each crop.

Summer die-back of apples and pears in the Royal Horticultural Society's Gardens in Wisley, Surrey, has been attributed to a deficiency of copper, which has been corrected by the addition to the soil of 8 oz. of copper sulphate per tree, by spraying the trees, when they are dormant, with a 4% copper sulphate solution, or by a 0.05% copper sulphate foliage spray.

In *New Zealand* hundreds of tons of copper sulphate are now being employed each year to maintain the fertility of a vast acreage of copper-deficient peat lands where top dressing of pastures with 5 lb. copper sulphate per acre has been found very beneficial. It is also often applied mixed with superphosphate in the ratio of



Copper deficiency in wheat. Withering and twisting of the young leaves
Crown copyright

½ cwt. copper sulphate to one ton of superphosphate.

From *India* it is reported that some soils in Bombay State have responded well to copper sulphate; as little as 1 lb. copper sulphate per acre applied to the soil in which rice seedlings were grown prior to transplanting, substantially improved the final yield of grain. In South India the addition of 5 to 10 lb. copper sulphate per acre, along with the usual fertilisers, has considerably increased the yield of rice. Gains of as much as 820 lb. grain and 2,400 lb. straw per acre over the control plots have been recorded.

In *Egypt* the suspension of a bag containing 5 lb. copper sulphate per acre in the water at the intake of an irrigation channel to control algal scums was observed also to have a marked stimulating effect on the growth of the rice.

From *Trinidad* in the West Indies, it has recently been reported that an experiment in connection with the use of copper sulphate to control snails in rice fields has also incidentally given a better early growth of the rice.

In *South Africa*, 15 lb. copper sulphate per acre with 155 lb. of a standard NPK fertiliser has substantially enhanced yields of wheat in the copper-deficient Coastal Belt. The application of 50 lb. copper sulphate per acre

to the soil, or 30 gal. per acre of a 0.4% solution of copper sulphate sprayed on to young sugar cane plants greatly improved their appearance and within three months after treatment they were 2 ft. taller than the untreated plants.

'Yellow Tip' or 'Reclamation' disease which affects cereals, sugar-beet and leguminous crops in various parts of *Europe*, notably Holland and Denmark, has been traced to a deficiency of copper. It is controlled by the application of 50 kg. copper sulphate per ha. applied in the spring, either mixed with fertiliser, or mixed with sand to facilitate application.

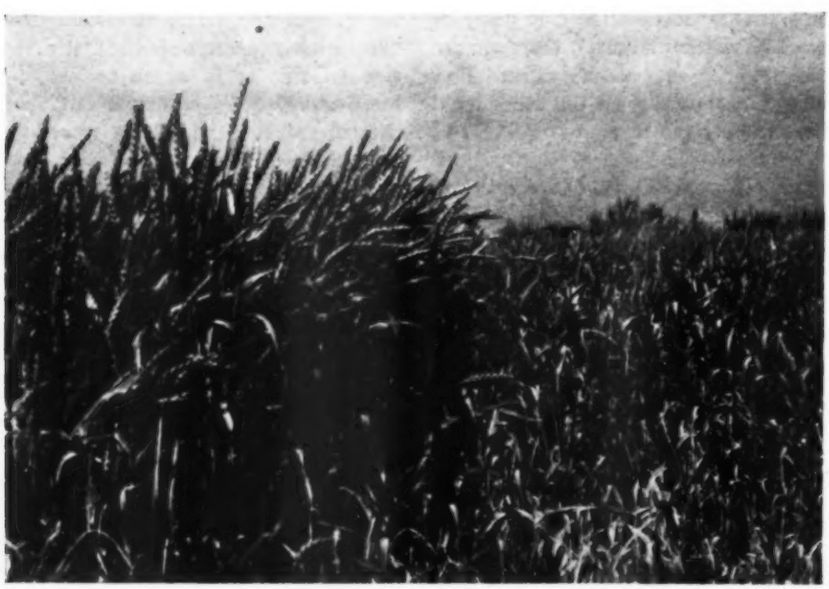
In *America* where copper deficiency was first observed on the raw peat soils of the Florida Everglades, very substantial quantities of copper sulphate are distributed annually by manufacturers of fertilisers, and magnificent responses have been obtained from the inclusion of this trace nutrient in fertiliser mixtures in copper-deficient areas. From Connecticut it is reported that the addition of 20 lb. copper sulphate per acre along with the usual fertiliser application to tobacco increased the yield by 175 lb. per acre without any adverse effect on its burning qualities.

Copper deficiency in tung has been reported from the Northern Peninsular area of Florida. The addition of 1 lb. copper sulphate per tree or spraying the foliage with an 8 : 8 : 100 Bordeaux mixture (8 lb. copper sulphate 8 lb. hydrated lime and 100 gal. water) corrected the deficiency.

Copper-deficient soils

Although our knowledge of the extent of the problem is still far from complete, it appears that most clay soils are sufficiently endowed with copper. A deficiency of the element is normally only associated with sandy soils; with soils rich in organic matter, i.e. peat soils; and with heath, scrub or moorland. Crops grown on any of these types of soil, which, in the presence of adequate water, fail to respond to the major NPK nutrients should be suspected as being deficient in copper. This, of course, does not mean that the factor limiting plant growth will necessarily always be found to be copper. Indeed, it may well be any one or a combination of trace elements, such as boron, magnesium, manganese, molybdenum, zinc etc.

Experimental techniques are now available for supplying all the major and trace nutrients except the one to be tested, thus making it possible to assess which particular nutrients are lacking in the soil.* A simple rough-and-ready test of the availability of copper in a soil is to apply small amounts of powdered or granulated copper sulphate in strips about 25 ft. wide across the field along with the normal NPK fertilisers, and observe its effects on suitable indicator plants such as maize, wheat, oats, spinach, lettuce, etc.



Wheat growing on a peat soil in the Fens of England. Left: *Foliar spray using ¾ lb. copper sulphate/acre.* Right: *Control – no copper. The yield increase is about ten times or about 30 to 35 cwt. per acre*

Copper-deficiency symptoms in plants

Copper deficiency symptoms only become visible when the deficiency is very acute. They vary with each kind of plant. Characteristic symptoms in cereals for example which usually grow normally until they are about 6 in. high, are stunted growth, withering of the tips with a spiral formation of some of the leaves, and the flowers fail to fertilise resulting in many of the ears remaining unfilled. Fruit trees grown in copper-deficient soils may develop a marginal chlorosis of the tips of the young leaves which wither and drop off. Die-back of the shoot follows. The bark becomes loose and the capacity of the tree to fruit is decreased. There may also be excessive gumming with stone fruits.

Copper-deficiency symptoms in animals

What was probably the first discovery of copper deficiency among animals was made in Holland in 1933, when it was found that dosing cattle grazing on reclaimed land with copper prevented a condition known as 'Lechsucht.' Since then similar disorders have been observed on copper-deficient pastures in the U.S.A., Australia, New Zealand and the U.K., and known by various names such as 'salt sickness,' 'falling disease,' 'Coast disease,' etc.

Among sheep 'swayback' in Britain and a similar affliction, known as 'enzootic ataxia' in Australia and New Zealand, causes lambs, born of ewes maintained on copper-deficient pastures, to develop a form of paralysis, particularly of the hind legs.

Summary

Deficiency of copper occurs pa ticularly on peat, in soils of high humus content, and also on very sandy soils, with a low humus content. Copper toxicity may result from adding too much copper to soils but a trace of copper added in the form of copper sulphate can be remarkably effective in restoring the fertility of such copper-deficient soils.

* Diagnosis by Subtraction (World Crops, 1957 9, 225)

Photos: By permission of the Controller, H.M. Stationery Office.

The Potato

Its Production and Consumption

A. E. COX, B.SC. (AGR).

THE world distribution of the potato – *Solanum tuberosum* – shows a marked concentration in middle and high northerly latitudes. The greatest acreage is to be found in central and northern Europe, between lat. 48° and lat. 60°N, but the crop is remarkably adaptable and it can be grown under such widely different conditions as the far north of Sweden, above the Arctic Circle, and in southern California.

Today the potato is an important world crop. Its introduction into Europe is variously attributed to Raleigh, Hawkins and Drake, but it was probably the Spaniards who gave us the potato. Subsequently it was introduced into N. America and Australia from Europe, and not direct from its original home in Peru.

Production

Europe is responsible for 75% of the total world production and the largest acreage is to be found in U.S.S.R., which produces over 30% of the world crop of potatoes, mainly in European Russia. Germany and Poland come next in terms of acreage. The U.S.A., with 1½ million acres, is a comparatively small producer, as also is Australia.

Potatoes are an important crop in a number of South American countries, notably Peru, Argentina, Brazil and parts of Chile. The Mediterranean countries are favourably placed to produce a high-priced 'early' crop for export to countries further north, but total production is low. The countries of Asia are also small producers in relation to their huge populations, the one exception being Japan. In Africa few potatoes are grown.

The total world acreage under the crop is now about 57 million acres, or one-eighth of the land under wheat, the leading grain crop.

Consumption

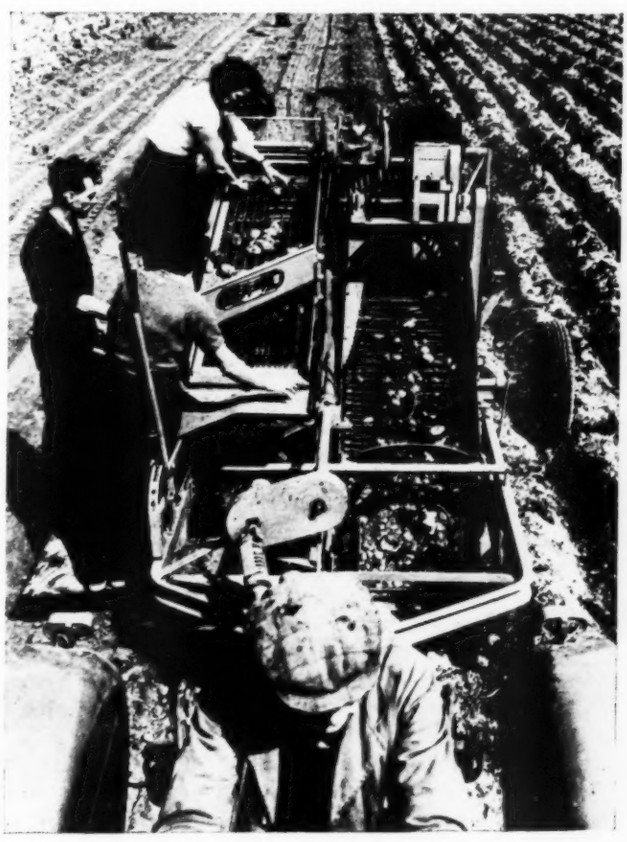
The main utilisation is for human consumption. A high rate of consumption – as much as 400 lb. each year per head of the population – is associated with a comparatively low standard of living. This is typical of the countries of central and eastern Europe, and of Eire. As living standards improve potato consumption goes down. Thus, in Great Britain annual consumption is around 200 lb. and in the U.S.A. and Canada between 100 to 150 lb. Difficulty is being experienced in North America in maintaining present levels in face of competition from other vegetables, and this is being met by putting potatoes on to the market in more attractive forms, such as pre-packaged, washed and waxed potatoes, frozen fried potatoes etc.

In many European countries potatoes have important uses for livestock feeding, principally to pigs, and for industrial purposes in the manufacture of potato flour, *farina*, and alcohol. This is a great advantage, as the ware market is cushioned against gluts and shortages arising from annual variations in yield. The tendency is for less potatoes to be used for feeding livestock and other purposes, as living standards rise and the labour becomes correspondingly more expensive.

As potatoes are a bulky and perishable commodity, they are generally consumed in the country of origin, although some long-distance movement of ware, particularly 'earlies', does take place, and there is a considerable trade around the world in seed potatoes from certain countries, notably Holland, Denmark and Scotland.

Yields

The wide variation in potato yield between different countries is striking.



A modern potato harvester and grader passing through a field of potatoes. This tractor-drawn machine permits stones to pass without injury to the moving parts and the clods are separated from the tubers before grading
Photo: Robert Eden & Co. Ltd.

The highest average yields are found in north-west Europe (Holland and Belgium), where they are around 10 tons per acre; in adjoining France they are only 5 tons per acre. In the U.S.A. yields vary considerably in different regions. Thus in Maine yields approximate to those under the best European conditions, but in the U.S.A., as a whole, the average yield is only just over 5 tons per acre. The lowest yields in the world are found in some of the countries of Central and South America, Asia and Africa, where the average annual output is less than 2 tons per acre.

Temperature

Potatoes are very susceptible to injury from frost and the length of the growing season in any area coincides closely with that period of time when frosts are absent. Very roughly, and depending on situation, frosts do not usually occur when mean monthly temperatures are at or above 50°F. There is a marked difference in the length of the growing period between certain continental conditions, when winters are long and severe, and maritime conditions, when winters are shorter and milder.

In continental situations, such as large parts of the U.S.A. and European Russia, the potato-growing season is short – approximately 120 days or less – and late varieties of potato may not have time to mature fully before harvest. In maritime countries like Great Britain, Holland and New Zealand the potato-growing season is long – 160 days or more – and late (maincrop) varieties have mostly died down some time before lifting. Growing in very northerly areas, such as Iceland and northern Sweden, is likewise handicapped by the shortness of the growing season.

The possibility of overcoming the disadvantages of a short season by breeding frost-resistant varieties does not appear to have a wide application. Under continental conditions the rise of temperature in the spring and the subsequent fall in the autumn is so rapid that unfavourable soil conditions will be a limiting factor to an extension of the growing season. A more hopeful approach would seem to be the breeding of quicker-maturing varieties.

Bushnell[1] has carried out controlled greenhouse experiments to determine the optimum temperature conditions for tuber growth. He found that maximum tuber production took place over the temperature range 59° to 64°F. If these limits are slightly widened, say to 58° to 65°F, this range covers the mean monthly temperatures found during the *latter* part of the growing season in those parts of the world with the heaviest yields – north-western Europe and north-eastern U.S.A. The latter part of the growing season can be defined as the last two months before maturity, during which time the bulk of the crop is produced. In practice, there are very few growing areas where mean monthly temperatures fall below 58°F at this time, although an exception is the Sierra or mountain zone of Peru, where the whole growing season occurs at a mean temperature of around 50°F, but yields here are very low.

In Bushnell's experiments tuber production ceased at 84°F and it has been found in Australia[2] that potatoes cannot be grown profitably when mean monthly temperatures exceed 75°F. There are not many potato-growing areas in the world where mean temperatures approach or exceed 70°F for any length of time. They are found, however, in some Mediterranean countries and under certain continental conditions. In parts of Africa and India potatoes are grown at high altitudes to avoid the excessive heat on low ground, and temperatures are sometimes suitable for cropping all the year round, but this practice is likely to cause trouble due to a carry-over of diseases and pests. In the Mediterranean countries two potato crops (a 'spring' crop and a 'winter' one) are grown during the same year. Temperatures at the height of the summer are too high for cropping.

Water

The amount of water available is the biggest single factor determining potato yield, but its measurement in terms of rainfall must necessarily be inexact. Direct rainfall is the normal water supply. Whether this is sufficient depends on its distribution, the rate of evaporation from the soil surface and the rate of drainage through the soil. For example, a relatively small amount of rain well distributed over the life of the crop which is typical of eastern England may produce a very useful potato yield. Under a sub-tropical climate like the 'new crop' growing areas of Florida, the same amount of rain falling in a few heavy downpours may lead to waterlogging of the soil and mechanical damage to the haulms with near drought conditions between rainstorms. In Australia what would appear to be a reasonable quantity of rain is very often insufficient owing to excessive evaporation and run-off.

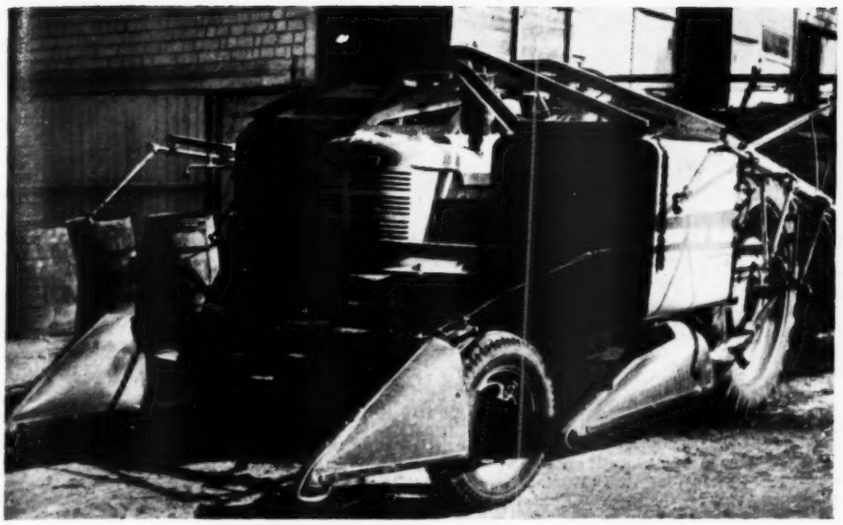
The normal amount of rain in those parts of the world where the highest potato yields are produced is between 2 to 4 in. for each month of the growing season. Rainfall is fairly constant from year to year under the predominantly maritime climate of north-west Europe and as a result there are no very large fluctuations in annual acreage yields. In the Netherlands yield variations are further modified by growing a large part of the crop at a controlled water level. But under fully continental conditions both rainfall and yields may fluctuate widely from year to year, and fundamentally this puts these areas in a weak position for marketing the crop.

Potatoes are grown on a small scale under very high rainfall conditions in the 'high valleys' of Mexico and in the hills of northern India during the summer monsoon period. The main difficulty here lies in controlling late blight, *Phytophthora infestans*, as the heavy rain not only favours the fungus, but also makes control operations difficult and less effective.

In some areas water has to be provided by irrigation. At Lima, in the coastal growing zone of Peru, average annual rainfall is only 1.8 in. and production would be impossible without large supplies of irrigation water. Other areas where rainfall during the growing season is very low include the western states of the U.S.A., the plains of northern India and the Mediterranean countries. In all these places water is let on to the fields along irrigation channels. The use of spray irrigation from above is also used on a small scale to supplement rainfall under temperate conditions.

Day length

Work on the photoperiodic response of the potato has been reviewed by Driver.[3] Maximum yields are to be expected when long days, which favour vegetative growth, are succeeded by short days, which favour tuber growth. These are the day-length conditions in the main potato-growing areas of the world situated in middle and high



A ' Farmall ' tractor equipped for spraying potatoes and fitted with wheel guards or vine lifters to allow the vehicle to pass through the crop

Photo: P. Grainger

northerly latitudes. The short days of equatorial regions lead to diminished top growth, maturity is speeded up and yield is decreased. Certainly, at the present, these are regions of low yields, but this is due to a number of causes and the view that short days are a decisive cause has been challenged.[4]

The very long days (over 20 hours throughout June in Iceland) of some northerly areas do not appear to have an adverse effect on yield. It is interesting that the potato yields in the most northerly provinces of Sweden (lat. 65°N) are as high, if not higher, than in the southern parts of the country (lat. 56°N), despite a shortened growing season.

Particular varieties show a definite photoperiodic response. Thus the ' early ' varieties of temperate regions are long-day potatoes, *i.e.* they have the ability to produce a crop under the long-day conditions of early and mid-summer. Short-day varieties, adapted to equatorial situations, would produce plenty of top growth, but no tubers under similar circumstances. The late varieties of temperate regions exhibit a day-neutral or short-day response.

This explains, for example, why a late variety, ' Sebago ', is grown almost exclusively in the ' new crop ' (or early) potato-growing section of Hastings in Florida, where day length varies between 10 to 14 hours during the 90- to 100-day growing season. A number of well-known varieties have proved themselves to be adapted to situations of widely differing day length. ' Up-to-Date ' is grown successfully in Scotland, Cyprus and South Africa; ' Kennebec ' has outyielded all other varieties in recent trials in Iceland and Florida.

Soil conditions

Most potatoes are grown on light well-drained soils. This is particularly necessary where the growing season is short, so that the soil dries out quickly at planting and lifting times. However, such soils tend to be low in organic matter, with a resultant poor moisture-holding capacity. Where the growing season is long, as in Holland and New Zealand, somewhat heavier soils (medium and heavy silt loams) make better potato soils. Texture must also be considered in relation to the increasing emphasis on mechanical lifting. In these circumstances organic soils like the English Fens and the muck and prairie soils in parts of the U.S.A. and Canada have distinct advantages.

Varieties and certification

For well over one hundred years the seed trade has been providing a multiplicity of new potato varieties for the farmers of the more technically advanced countries. As long ago as 1836, a classified list of 146 varieties was published in the *Agriculturist's Manual*.[5] In more recent years plant breeding institutes have added their quota. The importance of preventing a variety from being sold under more than one name has been recognised for some time. For example, over the past 35 years in Great Britain a Potato Synonym Committee has checked the names of all varieties and this has put an end to the type of abuse that led to the variety ' Sutton's Abundance ' being sold under at least 100 different names during the early part of the present century. In more backward countries the need to breed and select varieties suited to local requirements is only just being recognised. Of 54 varieties recently identified under cultivation in India, 38 were of European, but only 16 of Indian origin.[6]

The potato breeder aims to produce a high-yielding variety, resistant to disease and of good quality. Much emphasis has been placed in recent years on the breeding of varieties resistant to late blight. This work has been based on initial crosses between *S. tuberosum* and *S. demissum*, but, unfortunately, new ' blight-resistant ' varieties have quickly succumbed to specialised races of the fungus.

It is remarkable, in view of the amount of new material coming on to the market, how long the present-day principal maincrop potato varieties of the world have been in cultivation. This can be illustrated by listing a number with their year of introduction and the names of the countries in which they are the most important varieties: ' Bintje ' (1910), France, Belgium and Denmark; 'Majestic' (1911), England and Wales; ' Ackersegen ' (1929), Germany; ' Voran ' (1931), Holland; ' Katahdin ' (1932), U.S.A. This is a very different picture from that presented by a list of present-day varieties of a cereal crop such as wheat.

There is undoubtedly a large element of luck in the popularity of a variety, which can be illustrated by the case of ' Bintje '. This is high yielding, quick maturing and well shaped, but it is susceptible to wart disease, *Synchitrium endobioticum*, and common scab, *Actinomyces scabies*, very susceptible to late blight, and, although widely grown in Holland, its country of origin, practically the whole crop is exported, as the Dutch prefer to eat a more floury potato.

Many countries have seed certification schemes to ensure the purity of varieties and their freedom from disease, particularly virus diseases, leaf roll and rugose mosaic, and pests such as the potato root eelworm, *Heterodera rostochiensis*. An adequate supply of good certified seed is undoubtedly one of the chief reasons for the high yields of some countries, whereas the lack of sound seed stocks is the most pressing

problem for solution in those countries where yields are low.

There are considerable variations in the amount of certified seed used between old-established potato-growing countries. In England and Wales about 60% of the maincrop acreage is planted each year with certified seed; in France the figure is only about 20%, and this is an important contributory cause of low yields. On the other hand, there appears to be greater scope for the use of 'once-grown' seed in England and Wales. A 'seed plot', planted with high-class certified seed and grown in isolation with the aim of producing seed for the next year's ware crop, is an idea that might well be copied from growers in North America and New Zealand.

Healthy seed stocks can be maintained without great difficulty in areas where aphid activity is small, such as the important seed-growing districts of Scotland – Perth, Angus and Fife – but there are many less favoured countries where seed has to be produced under conditions of high summer aphid populations.

Potato blight

In Holland and France virus spread is largely controlled by the compulsory destruction of haulm in seed crops at an early stage (approx. mid-July), and this prevents the translocation of infection from the tops to the tubers. In Holland, too, much emphasis has been placed for many years on continually building up healthy stocks of a variety from single-plant selections raised in isolation. The building up of fresh stocks is also practised in the U.S.A. and Canada by a method known as 'tuber-indexing'. Three hundred tubers of a variety are submitted by the grower for testing during the winter at the local state or provincial laboratory. One eye is taken from each tuber and if, on growing, this shows signs of virus infection the tuber from which it came is discarded. From the original stock of 300 up to 20 tons of virus-free seed can be produced in two years, a result which is achieved by cutting the seed tubers.

Cultivations

The basic potato cultivations vary but little throughout the world. The land is ridged up over the tubers, except under special conditions like the black soil region of the Ukraine, where the crop is grown on the flat, as ridges would cause too much loss of water by evaporation and also loss of soil through erosion. Seed cutting is little practised, except in North America and Australia. This technique economises in the use of seed, but has been largely responsible for the serious spread of bacterial ring-rot, *Corynebacterium sepedonicum*, during recent years in the U.S.A. and Canada.

Chitting (or sprouting) of seed before planting is practised in a number of countries, particularly for early crops. This technique is used in the U.S.S.R., where it is referred to as 'vernalisation', and aims to speed up the maturity of the crop, thus increasing yield where the growing season is short and avoiding the worst effects of blight attacks. It is interesting that experiments in the U.S.A. under similar continental growing conditions have found no advantage from 'green-sprouting'.

It seems probable that the adoption of sprouting in the one country and not in the other is a reflection of the mechanics of planting. In the U.S.S.R., with a very abundant labour force, planting is by hand; in the U.S.A. mechanical planting of cut seed is universal. In some situations, such as the Mediterranean countries, where two crops are grown in the year, the dormancy period of seed from the first crop may prove a problem when it comes to planting the second. A short rest period is a feature of some potato species, *e.g. S. Rybinii*, and of some varieties, *e.g.* 'Northern Star', but sprouting may be encouraged by the use of chemicals, principally ethylene chlorhydrin. High soil temperatures also act as an effective means of breaking dormancy.

Planting distances vary between different countries. In Europe the usual planting distance is 28 in. between rows, with 18 in. between sets for maincrop varieties. In North America these figures are 36 in. and 10 to 12 in. These differences seem to have come about more or less fortuitously, but the wider rows have the distinct advantage of allowing tractors and sprayers to pass through the crop with the minimum of damage. Guards (or dividers) are also fitted to the tractor and sprayer wheels in North America. A recent development in the U.S.S.R. has been the planting of potato crops on the square with from 24 to 28 in. between rows and plants.

Potatoes are usually generously manured. That the crop responds can be seen by the high yields obtained from the inherently poor, light sandy soils of Flanders in Belgium. Here heavy dressings of artificial fertilisers and farmyard manure are used. On smallholdings, where potatoes are grown, the peasants bring their cattle in every night throughout the year to conserve the maximum amount of dung.

Pests and diseases

The most important fungus diseases are late blight and early blight, *Alternaria solani*. Until recently these were controlled by the use of copper sprays or dusts, but dithiocarbamate fungicides, which originated in the U.S.A., are now widely used for their control throughout the world.

DDT is the most commonly used insecticide. It can be applied in combination with fungicides. In France, for example, the use of DDT against the Colorado beetle, *Leptinotarsa decemlineata*, has stimulated interest in spraying against late blight. The flea-beetle, *Epitrix cucumeris*, and leaf hopper, *Empoasca fabae*, are important pests in North America, and in Australia and the Mediterranean countries action has to be taken against the potato moth, *Gnorimoschema operculella*. The use of new insecticides, such as parathion, for the control of aphids is another weapon in the hands of seed-potato growers.

Pests and diseases are controlled by spraying. High-volume spraying rates have been determined empirically – 100 Imp. gal. per acre in Great Britain; 100 U.S. gal. per acre in North America (equivalent to 80 Imp. gal.); 1,000 litres per ha. in France (equivalent to 89 Imp. gal. per acre). Low-volume spraying techniques are now widely practised and the use of aircraft for spraying and dusting is increasing.

REFERENCES

1. Bushnell, J.: *Tech. Bull. Minn. agric. Exp. Sta.*, 1925, No. 34.
2. Bald, J. G.: *Pamphl. Coun. sci. industr. Res. Aust.*, 1941, No. 106.
3. Driver, C. M., and Hawkes, J. G.: 'Photoperiodism in the Potato', *Tech. Comm. Imp. Bur. Plant Breed. Genet.*, 1943.
4. Moreau, R. E.: *Emp. J. exp. Agric.*, 1944, **12**, 13-20.
5. Whitehead, T., McIntosh, T. P., and Findlay, W. M.: 'The Potato in Health and Disease', 1953, Oliver and Boyd Ltd., Edinburgh.
6. Pal, B. P., and Pushkarnath: *Emp. J. exp. Agric.*, 1951, 19, 87-103.

Making the Desert Blossom

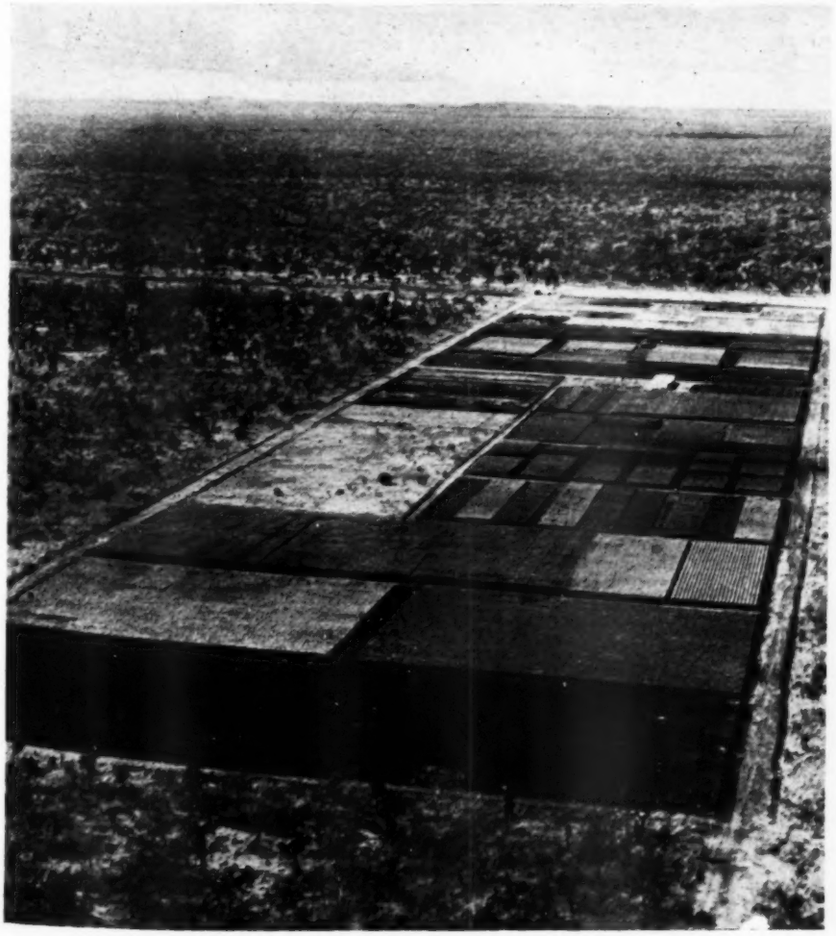
Pioneering the Modern Way

BRIAN JOHNS

Australian methods of discovering the best uses of underdeveloped land in their Northern territories could produce equally remarkable results, if applied in Asia.

THE Australian Government, being eager to speed up the reclamation of underdeveloped lands, has adopted methods which have made it possible to survey and map nearly 500,000 sq. miles (almost half the size of India) in Australia and 7,500 sq. miles of Papua, New Guinea in the last twelve years.

The officer-in-charge of the operations, Mr. C. S. Christian, began work in 1946 and a few months later the first survey unit proceeded to the remote and semi-arid country of central and northern Australia. This area is subject to drought, intense heat and scouring winds and at present provides barely enough scrubby pasture for grazing cattle. The harsh conditions prevented the units from remaining in the field for more than five months of the year and in an area where a wrong direction or a faulty supply could well mean death, the survey programme needed to be planned with the precision of a military campaign.



Above: *A survey and mapping unit operating in remote and arid country*

Left: *Experimental area of the Katherine Research Station in the Northern Territory*

Method and equipment

The Royal Australian Air Force first provided the aerial photographs of the region from which the course of the field work was plotted. A National Mapping Division in Canberra supplied maps which were used to decide the location of base camps, the fuelling and supply points, and the possibility of using existing roads and tracks.

Each operational unit was equipped with vehicles, a mobile workshop, camping and mess equipment, medical supplies, the necessary scientific

(*Continued on page* 340)

At Levington there are 82 field experiments with over 4,000 plots. Here two people are weighing and recording samples of herbage

Testing and Proving Fertiliser Mixtures

D. W. DUKE-WILLIAMS, M.A. (CANTAB)

RESEARCH work at Levington is carried out on fertiliser as a product as well as on the use of fertiliser, for which sound recommendations and advice are required. In view of this it is better to consider Levington as a fertiliser research station rather than as an agricultural research station, because it has a specialised part to play in the general field of agricultural research.

The scientific work of the station is divided between the Department of Soil Science and the Department of Chemistry. The Soil Science Department deals with soil and agronomic problems, seeking the greatest benefit from the combination of natural factors and the use of fertilisers. Fundamental studies and experimental investigations of materials in laboratories, pot trials and field experiments are supplemented by extensive field trials on the lands of co-operating farmers and growers.

The Department of Chemistry investigates new and improved processes for producing plant nutrients in forms which have suitable properties in manufacture and handling and use.

Recommendations for the use of fertiliser mixtures are based on the results of field trials, pot experiments and laboratory investigations. The following is an account of the work of the Levington Research Station, Suffolk, England.

Although the work of the department represents approximately half the scientific endeavour of the station as a whole, it is technological research on the product itself and is therefore outside the subjects covered by this article.

The Department of Soil Science

Laboratory studies are carried out by the Fundamental Group of this department.

The Soil Chemistry Section has made the soil-plant phosphorus relationship the main problem for investigation. The isotope of phosphorus P_{32} is used extensively in this work.

The group also includes the *Biochemistry Section*, where work is now in progress on the study of the nature of phosphorus compounds in plants using the new tracer techniques. An automatic chromotogram scanner for the detection and determination of P_{32} will now be used to augment the normal analytical techniques. The object of these studies is the determination of the phosphorus requirements of plants.

In the *Biology Section* the work is mainly concerned with problems associated with plant-soil micro-organisms relationships, organic matter decomposition studies, and the relation between host nutrition and disease incidence. This work has been extended to the field where preliminary results obtained indicated a reduction in the incidence of potato blight disease on the foliage with increasing levels of nitrogen and potash.

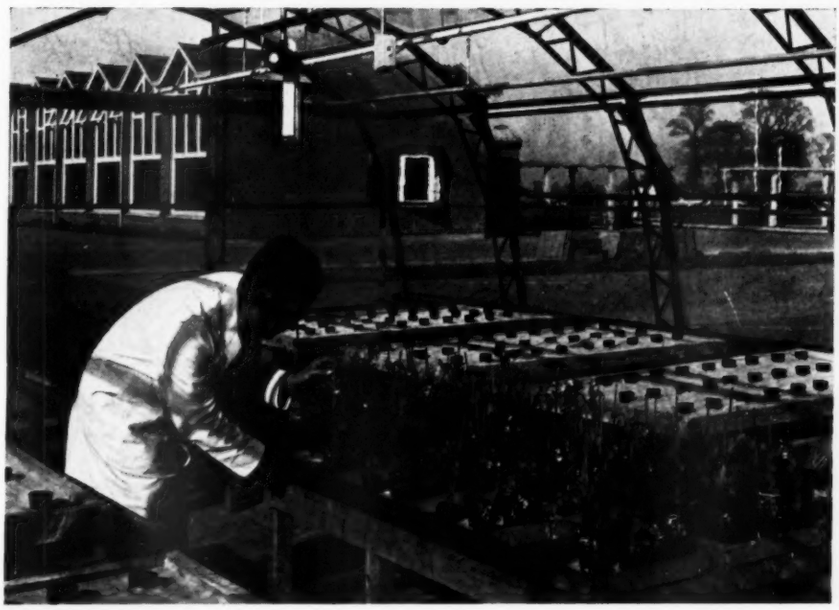
Pot trials are the link between the laboratories and field experiments. Among other things of interest is the sand-bed cultural technique, in which pots stand in a bed of wet sand, thus supplying water to the plants by upward absorption, has been examined using various sizes of whale-hide pots and various crops. It has proved to be a very satisfactory method for most crops and most types of experiment.

Some difficulty was experienced at first in obtaining satisfactory germination of seeds, but this was overcome by sowing the seeds on the surface of the soil and covering them with a layer of wet vermiculite, ¼ in. deep.

Field experiments are carried out either on one of the two farms attached to the Station itself or at the sub-station farm at North Wyke in Devonshire, or in the provinces. In all there are 400 experiments, comprising 16,000 plots covering agriculture and horticulture. The provincial field staff is made up of 10 officers situated throughout the British Isles, so that experimental results can be obtained from the wide soil and climatic variations that exist in Britain. Each officer supervises annually in his area about 800 plots, mainly in statistically designed experiments. In addition to field experiments on the farms at Levington, about 70 acres are used for demonstrating effects of various rates of fertiliser treatment and estimating their profitability. Areas that are not suitable, either for experiments or demonstrations are farmed commercially, making use of a Red Poll dairy herd on a 100-acre unit, which comes into this category, as a demonstration of cheap milk production.

There is also a *Horticultural Unit* at Levington consisting of top fruit, apples and pears; soft fruit, strawberries and blackcurrants; outdoor vegetables and flowers; tomatoes, cucumbers and carnations, in glasshouses; and a fine turf area. This unit provides facilities for fertiliser experiments on a wide range of horticultural crops.

The *Analytical Section* carries out analyses on some 60,000 soil and crop samples each year. About 30,000 of these are soil samples, which is part of the Company's advisory service to farmers and growers. The remainder are associated with the research work being carried out. Considerable attention is being devoted in this section to the application of mechanisation and automation technique to facilitate these analyses.



Above: *The phyto-solarium is designed to give maximum light and efficient temperature control. The pots are set in moistened sand to supply water to the plants by upward absorption*

Left: *A pH determination with a portable meter in the phyto-solarium*

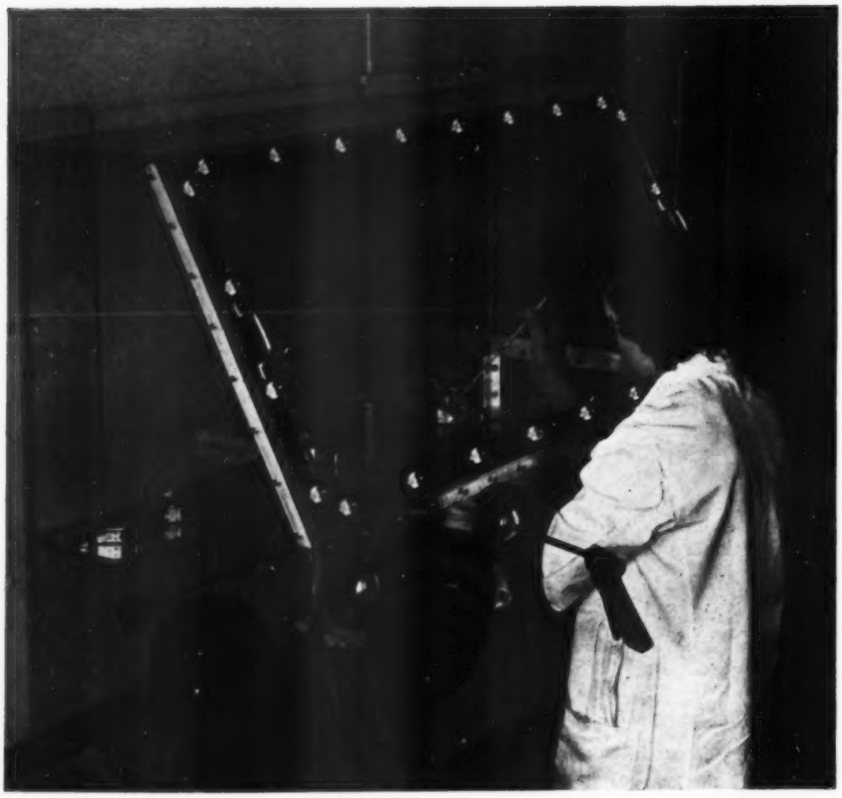
Experimental results

Although officially the Station was only opened on 7 May, 1957, field and pot experiments had been carried out at Levington since 1956 and some of these results are discussed below:

Two pot experiments investigated the scorch damage related to top-dressing nitrogenous fertilisers on grassland. Fertiliser in contact with the leaf produced localised necrosis, which was most severe from the most alkaline source and which decreased in severity with fertilisers of lower *p*H.

In long-term pot experiments measuring the rate of release of nitrogen from standard inorganic and organic sources, including ureaformaldehyde, the first season's growth showed that the rate of release of nitrogen from ureaformaldehyde is slower than from other sources; also the rate of release from some types appears to be maintained at a constant level for a longer period than with other organic or inorganic sources.

Field experiments examining the effect of magnesium applications in combination with other nutrients on pure grass swards, with particular reference to magnesium content of the herbage, confirmed many previous results on this subject and showed that it is possible to raise the percentage of



Radioactive phosphorus – one of the latest tools of soil research – must be handled in a protective glass box

herbage magnesium by application of magnesium. High levels of nitrogen had a greater percentage magnesium effect and this was particularly marked when the nitrogen source was ammonium nitrate rather than ammonium sulphate.

At 11 potato sites, testing magnesium applications at low and high levels of applied potash, there was no indication of a widespread general need for magnesium on typical light potato soils even at high potash rates of application. Applications of manganese and copper were not successful in raising the yield of sugar-beet on six typical soils, and at five sites on oats no effect of these treatments appeared.

Good control of wireworm damage to potatoes by various insecticides incorporated in compound fertiliser was obtained. Tasting tests, which are a regular procedure in assessing products at Levington, failed to detect any tainting of the tuber by the insecticides even at high rates. Tecane incorporated in fertiliser at 3.75 lb. per acre achieved an 85% kill of wild oats in sugar-beet and increased yield of beet – a greater application rate is normally required.

The experiments to determine the effect on potatoes of rates of nitrogen, phosphate and potash and of different sources of nitrogen and potash showed that (*a*) insufficient potash is one of the causes of blackening of the tuber after cooking, (*b*) an extremely high rate of potash lowers the dry matter content (and therefore quality) and (*c*) sulphate of potash produces a potato of higher dry matter than does muriate of potash, besides increasing the ratio of seed to ware. The beneficial effects of potash on dry matter were further shown by the texture scores of the tasting panel.

From the foregoing it will be appreciated that there is a steady progression of work from fundamental studies in laboratories, to pot trials and then to statistically designed field experiments which are carried out under farming conditions. This ensures that the recommendations by the Company as to how and when their fertilisers should be used have been made only after careful experimentation.

Photos: Fisons Ltd.

Making the Desert Blossom

(*Continued from page* 337)

equipment and a radio transmitter/receiver for communications.

In the field a unit operated from base camps for periods of from one to ten days. Navigation was done by the use of the special maps provided, by aerial photographs, and by compass bearings and speedometer mileages. About four to five thousand miles were covered in each season.

The survey and mapping units each included a scientific leader and experts in biology, rock formation and soils and plants, who worked as a team and by comparing their findings quickly determined the vital characteristics of an area. After the first detailed study, they discovered a recurring pattern of hill crests, slopes and valley bottoms, each with characteristic soils and vegetation.

Land-use plans

Each officer on his return to headquarters in Canberra, assembled and summarised the data he had collected. The aerial photographs were re-examined and their interpretation was then extended to cover the whole of the region. A final subdivision and classification of lands was made and land-use maps incorporating all these features were prepared.

By comparing their results, the various units found that similar land patterns occurred even over vast areas. By closer study of a number of these, they were able to make scientific generalisations on the make-up of vast areas. This has enabled an area twice the size of Burma to be mapped and assessed for quick development.

Research and development

The Katherine Research Station was established in 1946 in the Katherine–Darwin region of the Northern Territory after experiments carried out by C.S.I.R.O. scientists had shown that crops could be successfully grown in the area. Two companies have already commenced rice production on land once thought to be useless for agriculture and the production of groundnuts, sorghum, tobacco and cotton.

New Publications

Copra Processing in Rural Industries

By A. Aten, M. Manni and F. C. Cooke. Pp. 122, illustrated. FAO Agricultural Development Paper No. 63, in English, French and German, Rome, 1958. $1.50 or 7*s.* 6*d.*

The increasing use of synthetic detergents in place of washing soap in which low-grade coconut oil was an almost essential ingredient serves to emphasise the increasing importance of producing high-grade copra, the oil from which is more likely to be used for edible purposes. Hence the present book, dealing with the technology of copra processing, is opportune, since it endeavours to provide a guide for agricultural leaders whose task is to encourage smallholders in less developed regions to improve their copra.

The book gives a general account of the coconut palm, methods of harvesting, seasoning, husking and shelling the 'nuts' and then deals *seriatim* with the equipment and technique of copra production, preparation of shell charcoal, quality improvement with sulphur dioxide, defects in copra by micro-organisms and insects, grading for quality, rural industrialisation based on coconut products, and concludes with a selection of nearly 150 references to literature on the crop. The value of the 64 illustrations would have been enhanced had they been produced on more suitable paper, and a book of this type, which will be used in the field, should have had a hard cover.

While this volume will prove most useful to those for whom it is intended, one cannot but feel that the best use has not been made of the authors' wide knowledge. Further, the desire for simplification of the subject has, in places, resulted in some ambiguity. Fourteen pages are devoted to descriptions of 'indirect continuous driers,' some of which are obsolete and probably all unsuited to small holdings; on the other hand, 'defects in quality caused by insects' is dismissed in ten lines. An omission concerns the relative merits of sun-drying and kiln-drying: the important point has not been made that the chief factor in producing first quality copra is that the drying process must be continuous, any check causing serious discoloration of the product, loss of quality and often entry of insect pests.

The reader will, however, find much useful information in these pages, especially in the particularly lucid sections dealing with direct driers, the drying process in direct kilns, and copra conflagrations—aspects of the subject of great concern to agricultural leaders. The book certainly meets a long-felt want, and will be welcomed by planters and by field and research officers, working on the important problem of the improved production of copra.

(We recall the previous publications in this series, 'Hides and Skins', 'Cassava', 'Olive Oil' and the 'Rice Glossary'. We understand that there will shortly be a monograph on 'Cocoa' — Ed.)

D. H. GRIST

Bookshop Service

Books reviewed in WORLD CROPS and all other scientific or technical **books** may be obtained from:

Technical Books,
308 Euston Road,
London, N.W.1.
Telephone: Euston 5911.

Other miscellaneous publications reviewed should be obtained direct from the addresses given.

Advances in Genetics

Vol. 9, edited by M. Demerec. Pp. 294. New York: Academic Press Inc. London: Academic Books Ltd. 1958. 70*s.* 6*d.*

The ninth volume of this review series, which is intended primarily for specialists, contains a further assortment of papers on inheritance in plants and animals. The six contributions in the current issue include two which, although mainly fundamental in approach, have a bearing on some practical problems in crop improvement.

Interspecific crossing is well known to be one of the most valuable methods the breeder has at his disposal for introducing desirable characters into crop varieties, and knowledge of the probable genetic causes of hybrid failure and sterility is obviously essential as a first step towards overcoming the difficulties often encountered. In 'The inviability, weakness and sterility of interspecific hybrids', G. Ledyard Stebbins makes an interesting survey of the theories and some of the evidence concerning the causes of death, retarded development or failure to reproduce. He also considers the problem of barriers to interspecific crossing in relation to the origin of species. Dealing with both plants and animals, the review does not altogether avoid the pitfalls of having so wide a range.

M. Westergaard deals with 'The mechanism of sex determination in dioecious flowering plants'. A species is said to be dioecious, if staminate and pistillate flowers are produced on different individuals. This mode of reproduction is of economic significance in a number of crops, *e.g.* asparagus, hemp and papaya. Since dioecism is inseparable from the question of the inheritance of other types of sexual expression, the review is inevitably broader in scope than its title suggests. It is in fact a useful résumé and critical discussion of much of what is known concerning sex determination as a whole in the higher plants. The scope is further widened by a consideration of the evolution of dioecism and the physiology of sex determination. It is, however, to be regretted that next to no reference is made to papers published after 1956.

Three other surveys are concerned with fungi and the remaining contribution deals with the population genetics of the fly, *Drosophila robusta.*

THERESA ASHTON

Drainage of Agricultural Lands

Edited by James N. Luthin. Pp. 620. Wisconsin: The American Society of Agronomy. 1957.

Drainage has resulted in the addition of millions of acres of highly productive land to the area under agricultural crops and yet the improvement, reclamation and preservation of land by drainage has really only begun. Large areas of waterlogged and low-lying land in all parts of the world still remain to be tackled if yields are to be improved.

In drainage operations we are primarily concerned with water tables, the movement of water through different types of soil, and the relationships that exist between water tables and crops. It is on this broad base that the monograph has been developed by the editor and a team of 17 eminent specialists.

The book covers the subject, beginning with the physical principles governing the movement of water through soil to the engineering aspects of land drainage. The vast scope of this monograph brings with it both advantages and disadvantages and with a team of authors there must inevitably be some overlapping of subject matter and duplication of material in different sections.

It is perhaps surprising that in Section V – Land Drainage in Relation to Soils and Crops – the subject of the use of soil moisture meters on the farm is not considered, though the theory of the tensiometer is dealt with in Section I – The Physics of Land Drainage. This, then, is more a book for the drainage engineer, the agricultural administrator, colonisation officer and the student than for the practical farmer.

F. C. COOKE

American Tomato Yearbook

Edited by Dr. John W. Carncross. Pp. 40. New Jersey: Rutgers University College of Agriculture, 1958. Price $2.00

A new feature in this issue are the names, addresses and projects of leading men and women engaged in various phases of tomato research in all parts of the U.S.A. and Canada. Other important items include three pages on tomatoes in Canada, a complete list of state agricultural colleges and experiment stations, a classified directory of business concerns serving the tomato field, a list of leading associations engaged in the tomato industry, and information on acreage and production, as well as information on how to obtain products and services pertaining to tomatoes.

A Correction

The World's Sugar by V. P. Timoshenko and B. C. Swerling. Stanford University Press. London: Oxford University Press. 1957. 52s.

The price of the above publication was incorrectly stated to be 8s.

East Malling Research Station

The Annual Report for the year ending September 1957 contains both the Administrative and Research reports on the work of the East Malling Research Station. The Research reports are divided into four parts, the first of which gives a summary of the work on the farm, including the experimental glasshouses and nursery. Part II provides a detailed review of the current research projects, together with a list of publications during the year. Part III, composed of research reports, is the largest. Although written in such a way that they provide adequate information for other research workers, many of the papers contain, particularly in the discussions, much of direct value to the practical fruit grower and will well repay his perusal of them. The full text of the Amos Memorial Lecture on Plant Viruses by Mr. F. C. Bawden is included in this part, together with papers on the newly selected semi-dwarfing rootstock M. 26, the field performance of heat-treated strawberry clones, work in progress on apple and soft-fruit breeding, magnesium deficiency in apples, the weed hosts of progressive wilt in hops, and phytotoxicity trials.

Bulletins for fruit growers form Part IV of the report, and this year deal with some of the effects of soil management practices on the soil, and the value of spray culture experiments for the study of apple nutrition, as well as the progress made during the year in research in fruit crops and in the study of hop diseases.

Obtainable from the Secretary, East Malling Research Station, near Maidstone, Kent, price 17s. 6d. or $2.50.

Cacao Swollen Shoot Disease

Technical Bulletin No. 4 of the West African Cocoa Research Institute is a review of the present situation as regards the control of cacao swollen shoot disease in West Africa. Work there on the cure and control of this disease, which is one of the most economically important plant diseases in the world, is summarised and discussed in the bulletin, which is based on published papers and numerous references in the Annual Reports of the Institute.

It is divided into two sections: the first on the cure of plants infected by heat therapy and chemotherapy; and the second on methods of control. At present the general method of controlling swollen shoot disease is to attempt to stop its spread by eradicating the obvious sources of infection. In future, methods may include the use of resistant or tolerant varieties, mild strains of virus, biological control and the use of insecticides.

Published on behalf of the Institute by the Crown Agents for Overseas Governments and Administrations, 4 Millbank, London, S.W.1, price 2s. 6d.

EPPO

Report of the International Conference on Oriental Fruit Moth and San Jose Scale held in December 1957. The conference urged the desirability of importing countries which had to reject infested consignments sending details of the reasons for the rejection to the embassies of the exporting countries, thus arousing official interest in the economic losses suffered by countries that export infested produce, which in turn would lead to improved control measures. Detailed notes on the discussions are given price 2s., or 120 F. fr.

Pests and Diseases of Foodstuffs in Store (*Europe and Mediterranean*). The report covers the period 1955-57 and is divided into three sections: insects and mites; fungus diseases; and rodent pests. The section on insects and mites also includes some general information. For instance, encouraging results have been obtained in Federal Germany and the U.K. where reports are regularly sent to the suppliers on the condition in which commodities are received. The appended list of insects and mites found in stored produce has been extended, largely on the basis of inspections of ships carried out by the Infestation Control Division of the Ministry of Agriculture in the U.K. Reports of outbreaks and control measures are included from each participating country. Price 1s. or 60 F. fr.

Obtainable from the European and Mediterranean Plant Protection Organisation, 142 Avenue des Champs-Elysées, Paris.

Machinery and Equipment

For Mountainous Country

The estate roads of tea, coffee and cocoa plantations in mountainous country are often so tortuous as to be practically impossible to negotiate with ordinary 2-wheel drive vehicles. In many places only a 4-wheel drive vehicle, capable of taking a sharp hair-pin turn on a steep slope and along paths choked with weeds and bush, can get through. During the heavy rains, when the mountain paths become impassable to most vehicles, the *Jeep* 4-wheel drive vehicles can get through with ease.

These cars are useful not only for bringing in food and medical supplies for the labour force, but also for the daily inspection of work in progress, for the carriage of sprayers and spray liquids to the site of operations and for the speedy removal of the crop from the field to the factory.

Wet-weather Haymaking

The *Gross* hay tedder is a rubber-tyred machine which will gather a single swath at speed, irrespective of whether the hay is damp or dry. It will deal with grass or straw in any state between fresh and dry, without clogging up, however thick the swath may be. The crop is left in an ideal state for baling, being then evenly dry and free from patches of excessive moisture. A *Ferguson* tractor will operate the machine in second gear if the crop is extra heavy, but it can handle lighter and drier material in top gear.

An Amphibious Tank-trailer

A useful vehicle for the mechanised farm is the new dual-purpose 2-wheel tank-trailer for 'Land-Rovers' and 'Jeeps' now being manufactured by *M. F. Robertshaw Ltd.* It is literally two vehicles in one, being designed to carry freight and liquids simultaneously. Typical applications are carrying crop sprays and solid fertilisers; fodder and water; milk and hay; water, sand, gravel and cement; and liquid fuel and field supplies etc.

The standard model has a tank capacity of 100 gal. and a freight capacity of approximately 1,500 lb.; the Mk. II can carry 50 gal. and 2,000 lb. of freight; and the tanker Mk. III will take 200 gal. of liquid and 500 lb. of freight. The liquid compartment is fitted with reinforcing baffles and with the necessary inlet and outlet orifices.

The chassis of these trailers are of welded steel and they can be used over the roughest country, being well sprung. They are also amphibious and can be floated across streams and other water barriers.

Reader Service

For further information on any item reviewed in this issue please write to:

Reader Service
WORLD CROPS,
Leonard Hill House,
Eden Street, London, N.W.1,
England

Two 'Jeep' 4-wheel-drive vehicles being used for bringing in coffee in hilly country

A 'Robertshaw' 2-wheel tank-trailer supplying fodder and water to cattle in the field

A Novel Dusting Machine

The outstanding features of the new 'Granula' duster just introduced by *Cook & Co. (Manchester) Ltd.* are (1) its simplicity, (2) the devices for ensuring accurate, continuous and uniform flow of dust or granules irrespective of their nature and density and (3) operator comfort.

Continuous flow is ensured by a gravitational feeder system in the hopper without agitation; accuracy by automatically establishing the powder or granules at a constant level and density in the flow line, so giving an even supply to the fan; and comfort for the operator by the introduction of a non-reversible reciprocating lever to drive through a gearbox giving a ratio of 52 : 1. When cranked at 60 r.p.m. the air is moving at 4,080 cu. ft. per min.

The dust particles or granules must pass through a mixing chamber in which they are uniformly suspended in air, moving at high velocity, before

being discharged into the atmosphere through a flexible tube, fitted with a deflector nozzle. Powder can be lifted to a height of 15 ft. and granules can be spread uniformly to a width of 12 ft.

The rate of application in each case can be varied by means of two opposing shutter plates and for powder it may range from 2 lb. per acre to 100 lb. per acre; granules are uniformly spread from two granules per sq. in. upwards over the 12-ft. swathe, depending in the case of powder on the material and in both cases on flow adjustment and the rate of progress of the operator.

The machine is supported on wide webbing shoulder straps and there is no chafing on the body caused by the movement of the forearm because its operation involves no physical effort; the forearm is always moving in a horizontal plane, which is not the case with a rotary cranking arm.

The machine is readily accessible for cleaning and there are no moving parts to go wrong. Obviously no special instruction will be needed to teach anyone to use this simple and reliable machine.

Jacking-up a Tractor

Farmers and planters who regularly have to jack up tractors for wheel changing and track adjustment will agree that the new ' Quick Lift ' jack, recently introduced by *Lawrence Edwards & Co. (Engineers) Ltd.* for the *International* B250 tractor, is just the thing both in the workshop or in the field. It consists of two inter-connected jacking frames or cradles, one for the front axle and one for the rear, the second being attached to the hydraulic lift. All that is necessary is to operate the lifting mechanism of the tractor to raise all four wheels of the tractor clear of the ground. The cradles can also be used independently. It is obviously quick and easy to operate and it needs no attention, as there is nothing to go wrong.

This inter-connected jacking frame is operated by the lifting mechanism of the tractor

One floor of a large seed-cleaning plant, showing the ducts which convey the cleaned but undressed seed from cleaners on the floor above to the powder dressers on the floor below. The bagging hoppers on the left are for seed which does not require dressing

Seed-Cleaning Plant

A new seed-cleaning plant with an overall capacity of 8 tons per hour, now in operation in Rutland, England, is believed to be the largest in Britain. This plant, which is designed to deal with wheat, barley, oats, pulses, grasses and clovers, is made up of machinery and equipment manufactured by *Thomas Robinson & Son Ltd.* The same firm produces a mobile unit, mounted on a trailer 24 ft. long × 8 ft. wide, for cleaning grass seed at the rate of 5 cwt. per hour. This is powered by seven independently operated induction motors and has push-button control.

A Dust-tight Valve

The ' Sureseal ' valve, manufactured by *W. S. Barron & Son*, effectively controls the flow of fine powders and, being totally enclosed, ensures that dust nuisance and spillage are eliminated. It can be fitted into various flow lines without impediment; the standard model allows for the valve to be totally open or closed; where intermediate positions may be required, alternative types of valve can be fitted. Operation is by two pneumatically-operated cylinders which open or close a 6-in. diam. flow line, either by remote control or directly by hand. This device would appear to be specially useful for bagging off flour from a hopper.

The ' Sureseal ' valve as attached to a hopper for bagging off grain and flour

For Effective Irrigation

The ' heart ' of an irrigation system is the pump. With an output of between 50 and 400 gal. per min., depending on the head, the *Martin-Markham* pump can irrigate between 50 and 100 acres at a time. It is a centrifugal pump of robust and simple design, requiring little maintenance, which is driven from the p.t.-o. of a tractor through smooth-running increasing gears.

The ' arteries ' are the seamless aluminium alloy piping, which is normally supplied by this company in 20-ft. lengths. This alloy is not only very light, but it also resists corrosion. A quick-coupling device gives a perfect pressurised seal between the lengths of piping forming the ' Rainmaker ' system. The ' pores ' or sprinklers are of the slow automatic rotating type, operated by the pressure of water on a balanced vane. This ensures a regular and even distribution of water over the land.

A Humane Goad

The *Wolseley* humane goad is an electric prod, actuated by two torch batteries, which is used to give an animal a small electric shock. This shock is harmless both to animals and humans, but is of just sufficient intensity to persuade the most stubborn beast to move on in the required direction. After a time the animals will even move on seeing the instrument, without being touched. This is infinitely to be preferred to the beating and tail twisting and all the shouting, which bruises and frightens the animals.

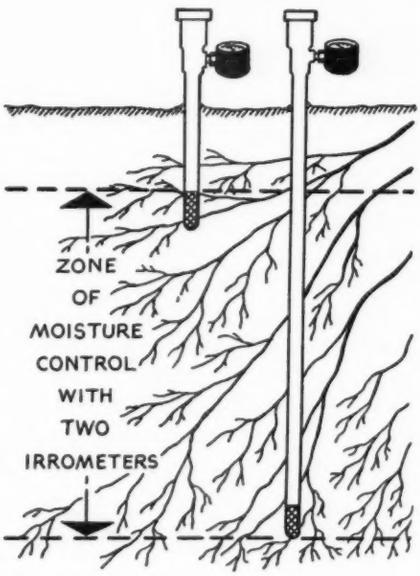
Mechanical Roots

It is claimed that the guesswork has been taken out of irrigation by the use of ' Irrometers '; these are instruments for the exact indication of the moisture condition in the vital root zone of the crop, which are manufactured by *T. W. Prosser & Co.*, of U.S.A. When used in pairs, these gauges are in effect a sort of mechanical root, which operates on the tensiometer principle.

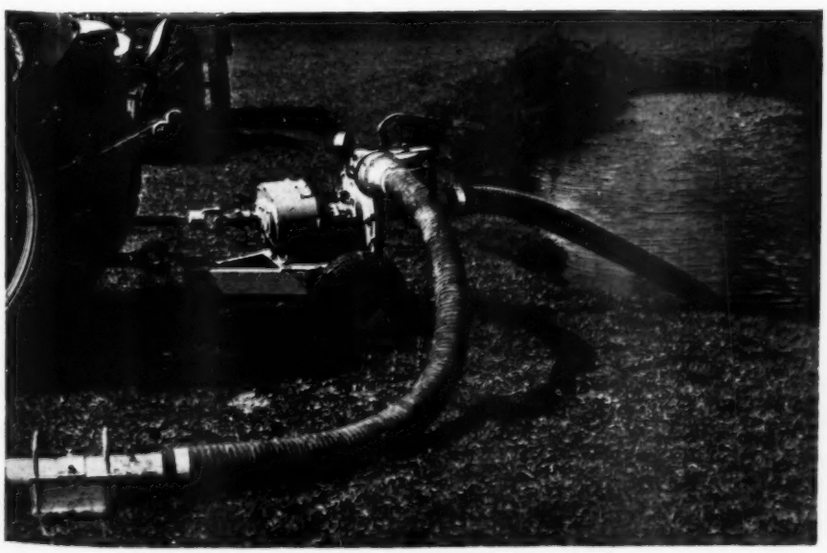
The control of irrigation by this system is based on individual 'stations', disposed over the field or orchard, which indicate the need for water in each irrigation block. The depth of the root system of the crop determines the depth or depths at which the gauges should be installed at each station.

For surface-rooting crops with root systems up to 18 in. in depth a single instrument is sufficient; for crops having root systems between 18 in. and 48 in. in depth, two depths per station are required – a ' shallow ' gauge with its porous tip at about one-quarter and a ' deep ' gauge reaching down to about three-quarters of the root zone. The shorter instrument tells when it is necessary to commence irrigation and the longer instrument when irrigation should be discontinued if the leaching of fertiliser is to be prevented.

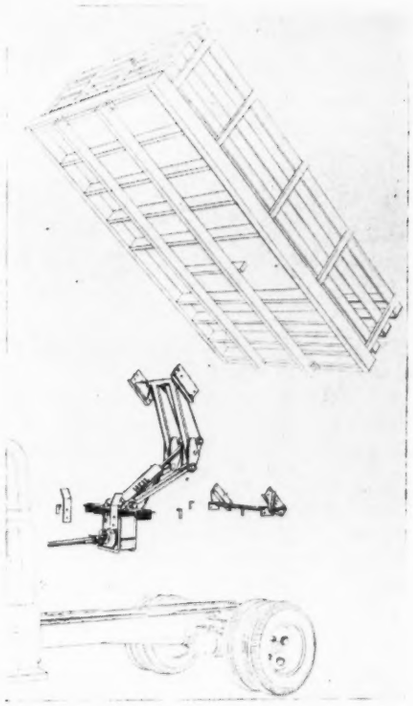
Thus the water requirements of the area immediately surrounding each station are known and it will then be possible to know when water is required and to conserve both water and applied fertiliser by preventing over-irrigation.



Two ' Irrometers ', as placed in the root system of a fruit tree, coffee bush or tea plant



A Martin-Markham pump drawing water from a river



The fitment to convert an ordinary lorry into a tipping unit is operated by a p.t.-o. from the transmission

A Truck Conversion

The *Heil Co.*, of U.S.A., has announced two new models of hydraulic dumping hoists to convert ordinary farm lorries into tipping units for the quick and easy unloading of grain, corn, soil, farmyard manure and other farm materials. These fitments can easily be mounted on any truck and any type of lorry body either by bolting them in position or by welding the hoist components to the frame of the truck or lorry. The hoist includes a hydraulic pump which is powered by a p.t.-o. from the transmission.

An All-purpose Sprayer

The ' Swathmaster ', a new machine for the aerial application of chemicals, fertilisers and seeds to farms, range and forest lands, has just been introduced by *Transland Aircraft*, of U.S.A. In this connection it is interesting to learn that 52 million acres of land in this country were treated by aerial applications in 1956.

This new dispensing unit will make it possible for the same aeroplane to dust, spray, seed or apply fertiliser as required simply by resetting the pilot valve and without wasting any time in landing to change the equipment. In other words, it can do the job of two aeroplanes, one equipped

Swath widths depend on the material being sprayed; they may be 33 to 100 ft. in width. Here potatoes are being treated with 30 lb. of zinc ethylene per acre

for dusting work and another for spraying liquids. The simple resetting of the pilot control takes only a few seconds and can be done while the plane is in the air.

The rates of flow are determined by the density or by the viscosity of the spray liquid. The makers claim that it can effectively dispense high- or low-density dry dusts; granular materials, seeds and pellets; emulsions and suspensions; and also the new jelly emulsions. It can lay a swath ranging from a minimum of 33 ft. to a maximum of 100 ft. at normal application speeds.

A New Forage Harvester

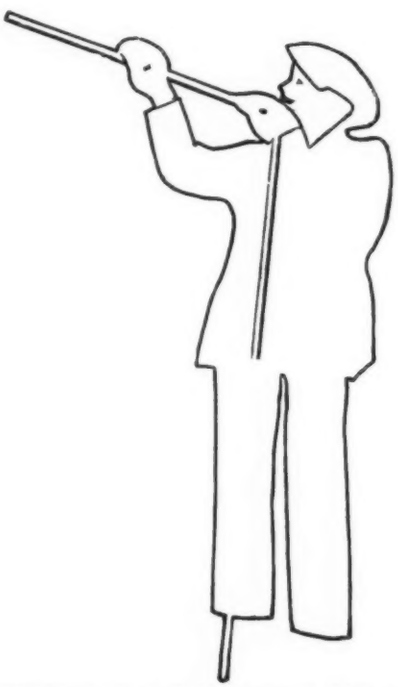
The wide range of tractors of varying power and age now being used on British farms presents a problem to the designers of forage harvesting machinery. A new forage harvester, recently introduced by *Silorators Ltd.*, is designed for use with a variety of tractors and even with a 'Land-Rover'. Its adaptability and low power requirements will appeal to farmers, particularly those who own the lower-powered tractors.

War on Locusts

To meet the threatened invasion of Kenya and Tanganyika by the desert locust, the Desert Locust Committee of the East African High Commission has decided to recommend the purchase of two more *Beaver* spraying aircraft and 100 vehicles for ground control. The aircraft will be used to assess the swarms as they enter Kenya and for spraying the locusts with a new concentrated insecticide when they are gathered in swarms in strategic areas. The vehicles will be used in the breeding areas in addition to operating in the areas under cultivation.

On Scaring Birds

Farmers will tell you that 'pigeons and rooks get used to anything'. Certainly they get into the habit of avoiding a familiar object which they fear and dislike, like the 'Coypu Maukin' bird scarer made by *North & Kinsman*. This is a ghostly white figure, armed with a dummy banger gun, which is moved to a new position from time to time. This scarecrow can also be associated with the noise of firing by the farmer shooting at the birds from a hideout with occasional subsequent reminders; the birds are thereby deceived and remain frightened by the figure.



The banger-gun of this fearsome object is operated by a rope by remote control

Flood Prevention

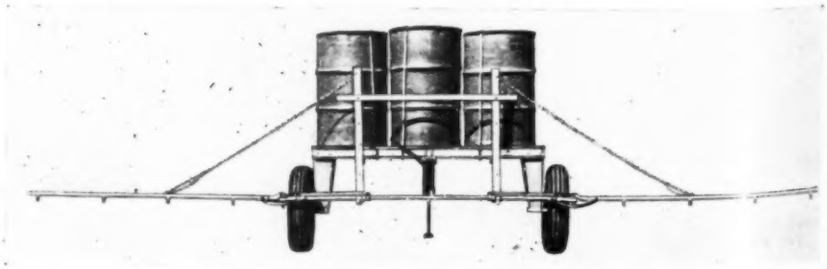
A graphically-illustrated, 16-page, two-colour booklet describing the problems and solutions of soil and water conservation, entitled 'Blueprint for Opportunity Unlimited', is offered by *International Harvester Export Co.*, of U.S.A. Designed to illustrate the programme of the U.S. Watershed Protection and Flood Prevention Act, the booklet describes the measures necessary for stopping and preventing floods, improving drainage, holding water fall, and the machines and tools to do the job.

Clean Grain

The *Garvie* grain and seed separator has three screens – one to remove very coarse impurities, a main screen to remove larger than grain size impurities, and the third to remove small weed seeds, sand, dirt and dust. The grain is drawn through the machine by two high-volume fans – one to draw the grain into the cleaner; the other for discharging the clean grain, the volume of air passing through each duct being separately controllable. The working capacities vary with the amount of impurities and the degree of cleanliness required.

Versatile Spraying

A new trailer-sprayer combination, suitable for a wide range of farm spraying, is offered by *F. E. Myers & Bro. Co.*, U.S.A. It includes a heavy-duty trailer which can carry up to three 55-gal. drums, a versatile folding boom with flexible supports for absorbing ground shock, and a Myers 'Du-All' pump with a wide range of capacities and working pressures. The wings of the boom are hinged and held in place by powerful springs; this prevents the boom from breaking, if it strikes a fixed object, and also makes it possible to fold the wings for turning, storage or transportation.



The new Myers trailer-sprayer combination

Agricultural Chemicals

Les Termites

This is the title of a useful little booklet on the subject of the ubiquitous termite, which has been produced by the French company, *Societe Xylochimie*. From this we learn that it was the French naturalist, M. de Quatrefages, who first discovered the extreme sensitivity of termites to chlorine. Naturally free chlorine, as such, is not at all suitable for the control of termites in field and forest and in the timberwork of farm buildings and estate jetties.

Xylochimie products, produced in various formulations for different purposes, are based on chlorinated derivatives of phenols, particularly pentachlorophenol and the chlorinated derivatives of benzene, such as hexachlorocyclohexane, combined with chlorinated solvents. These produce vapours which are highly toxic to termites and so will give anti-termite protection to buildings and wooden structures and control termites in the soil, especially under equatorial and tropical regions, where they are particularly prevalent.

Insecticidal Sprays

'Gammexane' Emulsion Concentrate is a clear, pale yellow solution, containing 20% gamma BHC, which may be diluted with either water or oil solvents. Which is used will depend upon circumstances. Where an oil diluent might create a fire hazard, water is used instead; if, on the other hand, there is a risk of water stain or any other damage, the concentrate can be diluted with a light grade of odourless kerosene or other suitable oil solvent. Water is, of course, more economical than oil, but oil itself has also some insecticidal action and where a quick 'knockdown' is desired pyrethrin extract can also be added, where an oil diluent is used.

Gamma BHC was originated by *I.C.I.* chemists and the present formulation is being marketed by *Plant Protection Ltd.* for use against flies, mosquitoes and termites; fleas and bugs; ants and cockroaches; and clothes moths, wood and carpet beetles. Aqueous sprays containing 0.5% gamma BHC are suitable for use in flour mills, breweries, godowns and storehouses, where foodstuffs and edible raw materials are handled and stored.

Basic Slag for Agriculture

Agricultural industry in Britain will be directly benefited by the recent installation of a Bessemer refining plant by The Steel Company of Wales. Since the war agricultural demand for basic slag has grown rapidly and home production has had to be supplemented by imports. The new plant will help by providing more than 150,000 tons of high-grade basic slag which will go a long way towards closing the gap between home demand and the domestic production of phosphates.

Most people know that basic slag is a by-product of the steel industry, but few realise that it is only certain methods of steel production which produce basic slag of agricultural value. The main sources of iron are phosphatic ores, non-phosphatic ores and scrap but it is only from the first that we get basic slag and it is this that is required for the Bessemer process.

The new supplies which will become available from The Steel Company of Wales will be marketed by *British Basic Slag Ltd.*, a company which has been associated with the marketing and use of basic slag in farming since the end of the last century.

Plant Growth Regulators

Plant hormones or growth regulators exhibit an amazing versatility. Applied to the growing plant, they can affect basic growth processes and alter growth patterns. These chemicals help root cuttings, minimise loss in transplanting, set fruit, thin apple blossoms, prevent pre-harvest fruit drop, or prolong the storage life of potatoes. They influence growth activity as they move downward toward the root, and throughout the transport system, whenever they are present or accumulate, they affect the plant. Natural hormones can cause plants to bend toward light or to grow tall; they can even cause severed leaves to form roots and eventually produce new plants.

Because it is expensive to extract natural hormones, chemists have developed synthetic analogues, which, when applied to plants, cause reactions similar to those of natural hormones.

Many synthetic growth-regulating substances are still only of experimental value; others have found immediate practical applications. They work effectively in minute quantities but none of them is a plant food or fertiliser, and the plant foods required for healthy growth must always be present in the soil.

A few of the products of the *American Chemical Paint Company* making use of these synthetic growth regulating substances are: 'Rootone' – which stimulates root growth and facilitates the rooting of cuttings; 'Fruitone' – which improves the set of fruit on apple trees, tomatoes and legumes; 'Transplantone' – which

'Rootone' stimulates the natural tendency of roots to form on slips or cuttings, so that a fuller root system develops. The cutting on the left was dipped in 'Rootone'

reduces the wilt and loss in transplanting vegetables, flowers and shrubs; and 'Amid-thin' – which replaces hand labour by thinning apples chemically.

Agricultural Packaging

The rapid transportation of high-grade produce such as pineapples, papayas, orchids and tropical flowers by air, rail or sea, necessitates special packaging. The *Bowater - Eburite Group* offer a wide range of lightweight materials in the form of specially shaped cartons and corrugated containers, pressed fibre drums and multiwall bags.

A Pre-emergence Weedkiller

Do your crop seedlings get away to a strong weed-free start, or are they held back by choking weeds during the first few vital days of growth? Are you worried by the lack of sufficient labour for hoeing, particularly if the weather turns against you, and by the high costs hoeing involves? Are you making all the profit you could from your crops, or are poor harvests and high husbandry costs seriously cutting your profits?

The use of 'Crestol' is the answer to these questions since if this spray is used there will be no competition from associated weeds for soil nutrients and moisture at the critical seedling stage, and so the seedlings will be able to establish a sturdy root system which will not be seriously sheared or damaged by the vibration of the mechanical hoes. Time and money will be saved because much less hoeing will be necessary, and singling or thinning out is easier and less costly because of the absence of weeds.

This product, according to the *Murphy Chemical Company Ltd.*, leaves no residual poison in the soil to harm the seedlings and no taint, even on such crops as carrots. It is also safe to use and special protective clothing need not be worn.

For Apple Mildew

'Sulpham' has been specially produced by *F. W. Berk & Co.* to meet the threat of the recent increase in the incidence of apple mildew. This formulation combines the well-known organo-mercury spray 'Phelam' with sulphur so as to give a dual-purpose fungicide to control both apple scab and apple mildew. It also exerts some acaricidal action which will check Red Spider. This product should obviously only be used for those varieties of apples that are not affected by sulphur. It is recommended for use at petal-fall with two or preferably three further applications at 10 to 14 day intervals.

Sleep Without Nets

Night in the tropics has a thousand small and secret sounds. Wind whisper and the temple gong, sudden skitter of lizard feet, click and tap, slither and rustle, the ceaseless *crik-crik* of cicadas under a great glittering moon.

Among these sounds comes the thin, wavering whine of a killer hovering unseen in the darkness, riding on diaphanous wings, bringing each year disease and misery and death to millions of farmers. It is estimated that in S.E. Asia alone, before malaria control was introduced, at least 50,000,000 cases occurred annually and that of these half a million died as a direct result of the disease. Today the menace is being driven from the scene by national eradication campaigns, slowly, surely, and progressively, using insecticides like dieldrin. Used as a residual spray to kill malaria-carrying mosquitoes, chiefly *Anopheles minimus flavirostris*, and also as a larvicide, this powerful insecticide developed by *Shell* is playing a major part in nation-wide spraying campaigns to eradicate malaria.

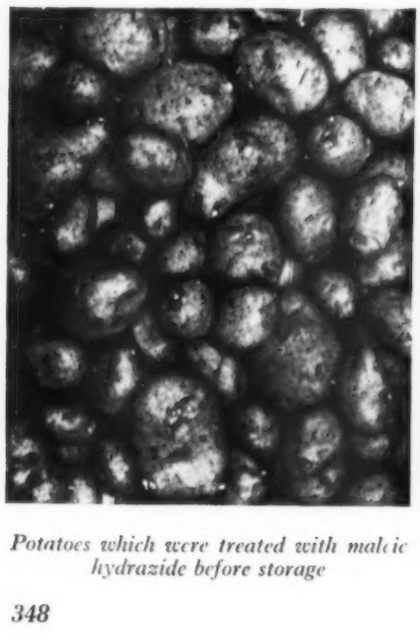
Growth Retarding

Maleic hydrazide or, more conveniently, MH has been known as a chemical compound for more than 60 years, but it was not until 1947 that its plant growth retarding properties were first discovered when research workers observed that it prevented the sprouting of stored potatoes.

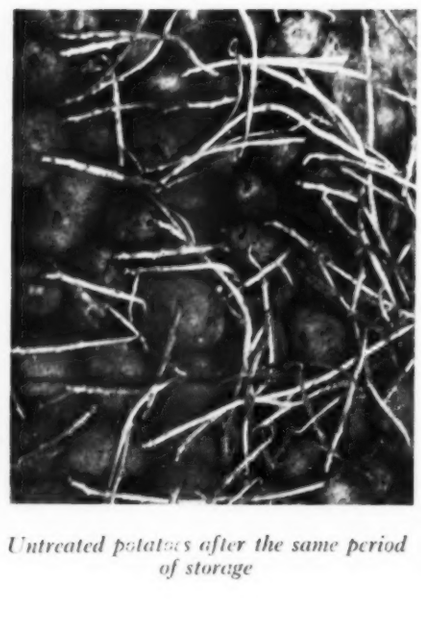
It has since been found that when it is sprayed on rough grass or hedges it temporarily prevents re-growth and so reduces the necessity for cutting and trimming. When sprayed on the top growth of root crops in the field, it also prevents subsequent sprouting during storage.

Field experiments and full-scale trials have been carried out in various parts of the world with the object of retarding the growth of tobacco suckers. Hitherto, these have had to be removed by hand – a costly and tedious business. But with the application of MH spray it has been found that such unwanted growths can be effectively inhibited, without any reduction in the size of leaf and yield, or any adverse effect on the quality of the tobacco, for MH does not kill the suckers, it simply stops them from growing; the large leaves continue to grow to their normal size.

MH is marketed by *Whiffen & Sons Ltd.* as a liquid preparation containing 25% w/v MH, which may be added direct to the spray tank, and also as a white, crystalline powder, containing 40% MH, which has to be dissolved in water before use.



Potatoes which were treated with maleic hydrazide before storage



Untreated potatoes after the same period of storage

World Crop Reports

Maize—a near-record

INTERNATIONAL REPORT

Maize

World maize production in 1957–58 is estimated at 6,470 million bushels, only slightly below the record production a year ago. Considerably larger crops than last year in Europe and South America were offset by smaller harvests in other areas, especially in the U.S.S.R. and North America. Total harvested acreage was below the 1956–57 acreage, but higher yields in the U.S.A., South America, and Eastern Europe maintained production at a high level.

The present estimate of world production is less than earlier forecasts mainly because of a lower estimate than was expected for maize harvested as grain in the U.S.S.R. Present estimates for Africa and South America are slightly higher than former forecasts because outturns in some southern hemisphere countries were larger than expected earlier. These increases, however, were minor, measured against the drop in the estimate for the U.S.S.R.

Maize production in *North America* is estimated at 3,610 million bushels, of which the U.S. crop of 3,403 million was 94%. The U.S. acreage was down 3 million acres, but yields averaged a record 46.8 bushels per acre. The reduced acreage, 72,656,000 acres of maize for all purposes, was the smallest harvested since 1885. Acreage in Mexico was also less than in 1956 and with below average yields the total production was 20 million bushels below the 1956 harvest. Production in Canada was slightly above last year mainly because of higher yields, though acreage also showed a slight increase.

Europe's 1957 maize production is estimated at 850 million bushels, compared with the small harvest of 685 million in 1956. The increase was in the Danube Basin countries where small yields in 1956 resulted in a very small crop for the area. Near-record yields in 1957, together with larger acreage, brought the total for the Danube Basin countries about 40% above the 1956 production.

Although maize acreage and production have expanded considerably in the *U.S.S.R.* since 1954, the outturn of 300 million bushels estimated for 1957 was well below the record crop of 575 million bushels in 1956. The decrease was due to a considerably smaller acreage and drought in a number of important regions.

Since a large part of the recent expansion in the U.S.S.R. was in areas not favourable to maturing maize as grain, substantial acreages are harvested each year for silage or green fodder. Acreage harvested as grain in 1957 was reported at about 15 million acres out of a total maize acreage of about 44 million acres for all purposes.

The maize acreage goal reported for 1958 is a little below the 1957 goal of more than 44 million acres. Thus, further expansion or production by the U.S.S.R., announced in 1955, has not materialised. Despite the late spring, plantings at the end of May for the 1958 crop were more advanced than at that time last year.

Maize production in *Asia* is estimated at 730 million bushels, slightly below the 1956 total. Some increase over the 1956 acreage is estimated, but lower yields in a number of countries offset the larger acreage.

Africa's estimated production of 395 million bushels was slightly below the 1956 total of 420 million. Smaller harvests than in 1956 for the Union of South Africa and Egypt account for the reduction. Yields were below the 1956 yields in both countries. Reduced acreage was also a factor in Egypt.

South America's harvest, recently completed, is tentatively estimated at 580 million bushels, the largest outturn of recent years, mainly because of the large crop reported for Argentina, due to increased acreage and high yields. The preliminary forecasts place that country's production at about 225 million bushels, more than double the small crop of last year. Production in Uruguay is also sharply above the small crop of a year ago, when yields were only about half of normal yields.

In *Australia* maize is of minor importance. A below-average crop of about 3.5 million bushels is estimated for 1957–58. Both acreage and yields were reduced by widespread drought.

REGIONAL REPORTS

Argentina

Argentina's 1957–58 *cotton* crop is estimated at 700,000 bales of 500 lb. gross. This is the largest Argentine crop on record. Production this season is up 46% from the 480,000 bales produced in 1956–57, and 24% above the 1955–56 crop of 563,000 bales. The bigger crop this season is attributed to an increase in acreage to a record level, and also to favourable weather at planting time.

The area planted to cotton this year amounted to 1,600,000 acres, an increase of 25% from 1,275,000 acres in 1956–57, and 21% above the 1,320,000 acres in 1955–56. Favourable weather at planting time, and high prices received by farmers for their cotton in recent years, were the main causes.

Outbreaks of leafworms, bollworms, and pink bollworms occurred in some areas during the growing season, but control measures apparently prevented excessive damage. Continuing rains in late April delayed cotton harvesting and caused some quality deterioration, especially in Chaco Province, which grows more than two-thirds of Argentina's cotton.

India

India's 1957–58 *rice* crop is officially estimated at 24,821,000 long tons of milled rice (83,473 million lb. rough), 12% below output in the preceding year. The revised corresponding estimate for 1956–57 is 28,282,000 tons (95,112 million lb.). Thus the decline is 3,461,000 tons milled or 11,639 million lb. of rough rice.

The small crop was caused by prolonged drought from September to December 1957 largely over central and north-eastern India. Bihar, Madhya Pradesh, Orissa, and West Bengal were the states most seriously affected.

However, generally favourable weather resulted in increased production in southern states. Andhra Pradesh and Mysore had substantially larger crops.

India's 1958 *wheat* harvest is tentatively placed at 325 million bushels. This is slightly below the record 1957

crop but is above average. Yields are indicated to be at the 1957 level despite low yields in areas affected by drought last fall. Unsatisfactory yields in those areas, especially Bihar, eastern Uttar Pradesh, and part of Mahya Pradesh, were offset by good yields in other areas, especially the Punjab.

Consumption of wheat and coarse grains in India is expected to be higher than last year because of increased availability of these grains and some shift from rice to other grains because of a smaller supply of rice. Larger crops of bajra and jowar account for most of the increase in coarse grain supplies.

The 1958 *cashew* crop has been damaged by early rains which have reduced both size and quality. Preliminary estimates place the harvest at 60,000 short tons, in-shell basis (including Portuguese Goa), or 17,000 tons less than previously forecast. Production of cashews in India and Goa was estimated at 71,000 tons in 1957.

Buganda

Figures issued show that growers earned £14½ million from their *cotton* and *coffee* crops during 1957, an increase of nearly £3 million over the previous year. Only once before, in 1955, have the farmers earned more money in a year.

The coming season's coffee crop is also expected to be big. The coffee trees are heavy with berries and flower, and experts believe there is every reason to expect a record crop.

Morocco

The *grain* harvest now under way in Morocco is considerably larger than the poor 1957 crop. The area seeded to durum wheat and barley was much larger than in 1957, especially the barley acreage.

Production of durum is forecast at 24 million bushels, compared with about 16 million in 1957. The estimated increase of 50% over last year's production is attributed to much higher yields and a 10% increase in acreage.

Soft wheat production this year is forecast at about 11.5 million bushels, compared with 7.5 million last year. Though well above the small 1957 crop, this is still below average.

Barley production shows the greatest increase of any of the grains over the small 1957 outturn. The current forecast of 55.5 million bushels is more than double the 21.5 million bushels harvested last year, but is still below average. Acreage and yields are well above 1957 figures, but are not up to average.

Lebanon

Wheat production in 1957 is estimated to have amounted to 70,000 tons, sufficient to supply nearly one-third of the country's requirements.

The *citrus* fruit crop of 1957 is estimated at approximately 100,000 tons, of which 53,000 tons were exported. Estimates for the *apple* crop of 1957 put the production at 38,000 tons, of which 23,800 tons were exported, principally to other Arab countries. The 1956 *olive* crop was abundant and produced 60,000 tons. Due to unfavourable weather conditions, however, the crop in 1957 suffered severely and produced only 10,000 tons.

Tobacco production in 1957 was in the region of 3.4 million kg., as against 2.4 million kg. in 1956, an increase of 40%. It is further estimated that 75,000 tons of grapes, 35,000 tons of onions, 40,000 tons of potatoes and 25,000 tons of bananas were produced in 1957.

Finland

Though less than forecast earlier, the 1957 *grain* crop was larger than the 1956 harvest. Larger oats and barley crops more than offset smaller outturns of wheat and rye.

Grain acreage was 25% less than in 1956, but larger yields, especially for oats, brought total grain production above the 1956 total. A good hay crop raised forage production 13% over 1956.

England and Wales

Cereals generally looked well at the beginning of July and yields were expected to be slightly above average but heavy rains during June and early July caused lodging which could become serious. Early *potatoes* were making good progress and the yield was expected to be about average. *Root crops* generally had made good progress but weeds were difficult to control. *Grass* made heavy growth during the month but haymaking was very difficult due to weather conditions. Except for short summer periods in the first half of the month, the weather during June was dull and cool and, apart from some north-eastern areas, very wet, with widespread thunderstorms at times.

Most crops of autumn-sown *wheat* were very good, with vigorous growth, although mildew was common in many eastern districts. Lodging due to heavy rain was reported to varying extent in eastern areas. Spring-sown wheat was generally vigorous and healthy and had suffered no significant storm damage. Autumn-sown *barley* was looking very well, although some lodging was reported. Spring-sown barley had made good growth in many areas and was generally satisfactory; mildew and lodging were reported from many districts. Reports on autumn-sown *oats* were variable. On the whole the crop looked promising but lodging and disease were reported in several areas. Spring-sown oats generally had made good progress, although attacks of mildew were severe in some areas. *Mixed corn* was satisfactory and was making good growth. *Rye* was an average crop.

Winter beans were generally a good crop, but 'chocolate spot' was reported. Spring beans were satisfactory on the whole; blackfly was common in a few areas. *Peas* for stockfeeding made vigorous growth in most areas. On the basis of crop conditions at the end of June, the yields per acre of cereals as well as beans and peas for stockfeeding were expected to be slightly above average.

Reports indicated that a few potato crops were affected by blight. Early potatoes were making good progress but lifting had been delayed by wet conditions.

Sugar beet was growing well and *mangolds* made satisfactory progress on the whole. The sowing of *kale* was almost complete, and earlier-sown crops were looking very well; pigeon damage was reported from some areas. The sowing of *turnips* and *swedes* had been delayed in a few areas, but generally germination was satisfactory and the crops were making good progress. Weed control in all root crops was difficult because of weather conditions.

Acknowledgement is made to *For. Crops & Mark.* and to *Spec. Reg. Inform. Services* for much of the information contained in the above reports.